# Understanding the Labor Market Impact of Immigration

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**Abstract**

In this paper I provide estimates of the impact of immigration on native wage levels (rather than wage inequality which has been the focus of the literature). I use variation within 2-digit industries across regions using Austrian panel data from 1986 to 2004 for identification. Using an instrumental variable strategy I find large displacement effects in the service sector and large native employment increases in manufacturing. This heterogeneous response is explained by large increases in output in manufacturing, due to a high elasticity of product demand, as immigration reduces the cost of production, while on average demand is far less elastic in service industries. Estimated substitution effects, for a given level of output, are large in both industries and in line with US estimates. The fraction of immigrants went from 5% to 15% of the labor force over this period; the estimates imply this reduced average native wages by around 4.7% and resulted in 5% of the native labor force changing industry, primarily from services to manufacturing. I extend the model to allow native labor to endogenously choose what type of labor factor to provide in an industry-region. The estimates suggest that in response to immigration, even within the same industry, natives change what they do.

# 1 Introduction

Over the past two decades there have been renewed large and primarily low-skilled immigration flows to most developed countries. On average among OECD countries the

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fraction of population that is foreign born went from 5.7% in 1988 to around 11% in 2005. Such large flows are likely to have significant social and economic consequences for the native-born population. One of the most controversial issues in the debate over immigration, both politically and in the economics literature, is whether and to what degree immigrant workers displace native workers and adversely affect their wages. Using a panel dataset for Austria I find that immigration increases the demand for native workers in manufacturing, but displaces native workers in services industries. This differential effect can be explained by manufacturing firms rapidly expanding output as immigration reduces their cost of production, while the demand for the output of most service industries is relatively inelastic. As a consequence the aggregate impact of immigration to Austria is a slight fall in average native wages and a substantial shift in native labor away from service industries to manufacturing.

The approach of this paper differs from that of the existing literature in a number of important ways. The first major departure from the literature is that I estimate the impact of immigration on the level of average native wages and employment, whereas previous work has focused nearly exclusively on the impact of immigration on relative wages and employment of different groups of native workers. The total impact of immigration on the demand for native labor is a combination of scale and substitution effects. The substitution effect is that, for a given level of output, an increase in the number of immigrants employed will result in a fall in the demand for native workers (provided the elasticity of substitution between immigrant and native labor is positive). However, an inflow of immigrants will reduce firms' cost of production and so output expands (provided that the elasticity of product demand is negative). As the scale of production increases on account of immigration, for a given relative wage, firms will employ more native workers. The magnitude of this scale effect depends on the elasticity of product demand, the more elastic demand is the larger the scale effect. The previous literature has focused on estimating the differential impact of immigration on natives in race/sex groups (Altonji and Card, 1991), different occupations (Friedberg, 2001 and Card, 2003), and education/experience groups (Borjas, 2003 and 2006, Ottaviano and Peri, 2006, and Borjas, Hanson and Grogger, 2008) and, hence, on estimating the elasticity of substitution between these groups of workers.[1] My approach uses administrative panel data on all Austrian employees in the period 1972 to 2004. I identify the impact of immigration over the period 1986 to 2004, where the number of immigrants as a fraction of the labor

[1] LaLonde and Topel (1991) and Cortes (2008) take an approach more similar to mine by estimating the impact of immigration on immigrant versus native wages. Card (1990) estimates the total effect of immigration on native wages and employment.

force went from 5% to 15%. I use the variation in immigration flows across Austria's nine regions within 2-digit industries, pooled over multiple years, to estimate the impact of immigration (1) on native employment in an industry-region, (2) on native wages, and (3) on immigrant wages. With the help of basic production theory I use these estimates to derive the scale and substitution effects arising from immigration, as well as the elasticity of labor supply across industries and regions. The elasticity of labor supply plays an important role since it determines to what degree shocks to the demand of native labor result in changes in relative wages or relative employment across industry-regions. Having estimated these parameters, and by assuming that in aggregate the elasticity of labor supply is zero (as in Katz and Murphy, 1992 and Borjas, 2003), I am then able to estimate the aggregate impact of immigration to Austria on average native wages.

Empirical estimates of the impact of immigration on native wages face two major challenges. First, immigrants do not choose their locations randomly. Unobserved economic factors that attract immigrants are likely to also affect native worker outcomes. Second, labor and capital are mobile and may respond to immigration by relocating across units of observation. The two main approaches in the literature address these challenges differently. The local labor market approach, first due to Grossman (1982), uses the geographic variation in immigration flows to identify the local impact of immigration. In this approach, following Altonji and Card (1991) and Card (2001), it is possible to instrument for the current distribution of immigration flows by using the historical distribution of immigrants across local labor markets. However, Borjas, Freeman and Katz (1996) and Borjas (2003, 2006) are critical of the local labor market approach arguing that it fails to take account of offsetting capital and native labor mobility across local labor markets, which will tend to attenuate the wage effects of immigration.[2] The second approach uses variation over time at the national level, where native labor supply can be thought of as inelastic, in the relative supply of different types of labor. The disadvantage of this approach is that it maintains the assumption that the composition of immigration flows is exogenous, for example, that changes in the return to education do not affect the educational composition of immigrants. My identification strategy combines the strengths of each of these approaches. First, identification is across regions within 2-digit industries, so that I am able to instrument for the distribution of the inflow of immigrants. Second, I explicitly model and estimate the response of natives to immigration and so am able to account for this effect when estimating the elasticities of derived demand. Finally, having

[2] Card and DiNardo (2000), Card (2001, 2005) and Card and Lewis (2007) find that there is near to no offsetting native labor mobility in response to immigration shocks. Borjas (2006) and Cortes (2008) find large, but not perfectly, offsetting displacement effects.

estimated scale and substitution effects allows me to construct estimates of the impact of immigration at the national level where the elasticity of labor supply can be assumed to be close to zero.[3]

I model production as a nested CES-aggregate of native and immigrant labor and capital. I assume that a native worker's discrete choice problem takes the form of a two-level nested logit, where workers can choose an industry and region within which to work. Whether immigration is a positive or negative shock to the demand for native labor depends on the difference between the elasticity of demand for labor (which in turn depends on the elasticity of final product demand) and the elasticity of substitution between native and immigrant labor. We would expect, in particular, the elasticity of demand to vary across industries. In manufacturing, where goods are internationally traded, we would expect a high elasticity of demand; whereas in service industries, where output is constrained by local demand, we would expect a low elasticity of demand. Hence, unlike previous studies, I estimate the impact of immigration separately by 1-digit industry.[4] I find that over the period 1986 to 2004 in all industries immigration results in a substantial fall in average immigrant wage, with an elasticity of -0.09 in services and -0.22 in manufacturing. The increase in the supply of immigrant labor results in a negative shock to the demand for native labor in service industries, the IV estimates suggest that around 0.6 native workers are displaced by the arrival of one immigrant and there is modest and not statistically significant fall in average native wages. In contrast, in manufacturing the arrival of one immigrant results on average in the employment of 1.3 additional natives and a small and not statistically significant increase in average wages. The heterogenous impact of immigration can mainly be explained by a very high elasticity of product demand in manufacturing and a low elasticity in services, with point estimates of 34 and 1.5 respectively.[5] In aggregate these estimates imply that the increase in the number of immigrants in Austria from 5% to15% of the labor force decreased average native wages by around 4.7% and caused around 5% of the native labor force to change industry, primarily from services to manufacturing.

The approach I take highlights a puzzle in the literature on immigration, and that is why immigrants and natives of similar observable characteristics seem to be imperfect

[3]The fact that, using US data, papers using varation across local labor markets have tended to find small effects of immigration and those using the time series methodology have tended to find larger effects suggests that reconciling these approaches is important.

[4]Specifically, I estimate an average impact pooled over all 2-digit industries within a 1-digit industry.

[5]My estimates of the elasticity of substitution between immigrant and native labor of 4 and 16 in manufacturing and services respectively are in line with estimates by Cortes (2008) who estimate an elasticity of substitution of 4 and Ottaviano and Peri (2006) who estimate an elasticity of substitution of between 5 and 10 using US data.

substitutes.[6] Moreover, since I do not find that the impact of immigration varies significantly for natives of different education I assume that these are perfect substitutes. This raises the issue whether there are other salient worker features that may explain these findings. Work by Autor, Levy and Murnane (2003) provides a plausible answer. They find evidence of shifting task specialization even among workers of the same gender, education and occupation in response to the shock of a fall in the price of computer technology. Cortes (2006) and Peri and Sparber (2007) apply this idea to understanding the impact of immigration and find evidence that low-skilled immigrants and natives specialize in manual and interactive tasks respectively. The ideal data for testing this hypothesis would be individual level panel data on the tasks workers are engaged in. To my knowledge such information is however unavailable. The US data used in these studies relies on information from the Census and work by Spitz (2006) uses four cross-sections of German data over the period 1979 to 1999, neither data source provides observations on individuals actually changing tasks. I take the complementary approach of asking whether individual level panel data without information on actual tasks provides evidence of task specialization in response to immigration.

In order to do so I adapt and extend the basic model to allow for endogenous task choice by native workers. I model production as a nested CES-aggregate of two task inputs and capital. Immigrants have a comparative advantage in one of these tasks and are perfect substitutes for natives engaged in the same task. Natives have to choose which task in what industry and region they will provide (taking the form of a three-level nested logit). I derive the elasticities of derived demand for this model, which retain all the well understood properties of Marshall's Laws of Derived Demand, but also account for the fact that workers can endogenously choose to change the task they supply while remaining within the same industry-region. The extended model yields additional predictions that are testable with individual level panel data. In particular, immigration will affect the hire and separation rate of native workers, as well as differentially affecting the wage of newly hired and incumbent workers. It turns out that this additional information provided by panel data is sufficient to estimate the parameters of this model of endogenous task choice and hence estimate the aggregate impact of immigration on task specialization and inter-task wage inequality.

[6] Local area studies tend to find that the impact of immigration on wages of immigrants is more negative than that on natives of similar observable characteristics, see Card (1990), LaLonde and Topel (1991) and Cortes (2008). This implies that immigrants and natives of similar characteristics are imperfect substitutes. The evidence from time series studies is less clear with Ottaviano and Peri (2006) finding evidence of imperfect substitutability and Borjas, Grogger and Hanson (2008) evidence of a very high degree of substitutability.

I find that two-thirds of the net increase in native employment in manufacturing is due to an increase in the hire rate of new workers, and one-third due to a fall in the separation rate. In services both the hire rate of native workers decreases and the separation rate increases, accounting for 60% and 40% respectively of the net decrease in native employment. In both industries the effect of immigration on wages is more positive for new hires than it is for incumbent native workers. The implication is that over the period 1986 to 2004 the fraction native workers engaged in the task where they directly compete with immigrant labor falls from 45% to 34% in services and 19% to 13% in manufacturing. This shift in the factor that natives supply to an industry is due to the impact immigration has on the relative wages accruing to the two factors. The implication is that the relative wage paid to those supplying the immigrant intensive task falls by 2% in services and 4.5% in manufacturing. This suggests that immigration does increase inequality among native workers even within the same industry, however that effect is mitigated by the ability of natives to change the type of task they are engaged in.

The rest of the paper is organized as follows. The data and descriptive statistics on immigration to Austria are presented in Section 2. Section 3 outlines a basic model with which to understand the impact of immigration. Section 4 describes the instrument, presents estimates of the impact of immigration on native wages and employment, as well as immigrant wages. I then show how these can be used to identify scale and substitution effects arising from immigration and what the implications are for the aggregate impact of immigration. In Section 5 and 6 I extend the basic model to allow natives to endogenously the type of factor they supply to an industry-region. I show how this model can be identified and provide evidence on the model's implications. Section 7 concludes.

# 2 Data

## 2.1 Dataset

The analysis in this paper uses a dataset containing social security records for all individuals employed in Austria between the years 1972 and 2005, with the exception that I observe tenured public sector employees only starting in 1988 (or in some cases 1995). The observations are specific to a match between an employee and employer in a certain year (so continuous employment relations are truncated into separate observations ending on December 31 and starting on January 1 of a year). Observations contain information on income and days worked, as well as the type of employment. Also recorded for individuals are their gender, nationality, date of birth, and location of residence. For the employer I observe their 4-digit industrial classification and location. I also observe spells of unemployment, maternity (or paternity) leave and, only for women, live births. There is some top-coding of income, which in no year affects more than 9% of employees; income is not observed for tenured public sector employees. There is also some bottom-coding of incomes, which in no year affects more than 8% of employees. Until 1997 only an individual's latest nationality and location of residence is observed. Education records are obtained from data provided by the Austrian Employment Service (AMS) and only exist for individuals who are unemployed at some point during their career. Apprenticeships during the period 1972 to 2005 are observed directly in the data. I impute education for everyone else.[7] I distinguish between low skilled (those with at most compulsory schooling), medium skilled (those having completed apprenticeships or vocational training) and high skilled (completed *Matura* or tertiary education). Notice that these definitions are very different than the ones employed in the US. Since I have longitudinal information on workers I can construct actual experience and actual tenure variables. Work experience prior to 1972 is imputed using the information on education and average employment rates for men and women in prior years. Observed income is nominal (in euros) and per day worked.

The unit of observation for most of the empirical work in this paper is a 2-digit industry in one of Austria's nine regions. I use the NACE economic activities classification scheme of the European Union. The exception is construction (itself a 2-digit industry), in which I use the 3-digit classification. I also combine agriculture with forestry and fishing to create a single industry. For around 16% of observations I have no information on the industry they work in (this is a problem primarily for the self-employed) and consequently I exclude them from the analysis. I exclude the public sector and non-for-profit industries from most of the analysis, reducing the sample size by 19%. I also exclude those industries that do not employ at least 20 foreigners in the period 1972 to 1979, accounting for 8% of native observations. Finally, since identification is (in large part) across industries I only include industries that on average employ at least 20 workers per year in at least six of the nine regions. This restriction reduces the sample size by 13%.

[7] For 35%of native and 29% of foreign observations education needs to be imputed. I impute education for individuals using a multinomial logit. The explanatory variables are gender, cohort, as well as income, 2-digit industry, region and type of employment at various stages of a worker's career, and, where available, a proxy for years of schooling. The within sample fraction of correctly imputed education levels for natives is 59%, and 53% for foreign workers. For natives the fraction that has to be imputed is 40%, 23% and 56% for low, medium and high skilled education groups respectively. The corresponding within sample fraction correctly imputed is 68%, 44% and 63% respectively.

## 2.2 Background

### 2.2.1 Immigration

During the 1970s until 1988 the percentage of employees in Austria who are foreign nationals is stable at around 4.5%. Then from 1988 onwards the number of foreign workers more than doubles in four years. From around 4.9% of those employed (180,000 individuals) in 1988 to around 10.5% (421,000 individuals) in 1992; after which it continues rising to around 15% (see Figure 1).[8] Up until 1989 most foreigners in Austria were from Yugoslavia, with a sizeable fraction from Turkey and an increasing number from developed countries. Following 1989 there was an increase in foreigners from all countries, but in particular Eastern Europe (see Figure 2).

Legally employed immigrants initially only have a temporary work permit (*Beschaeftigungsbewilligung*) valid for at least one year which ties them to a specific employer or are seasonal workers with are allowed to be continuously employed for at most nine months and for at most 12 out of every 14 months. After one year of employment immigrants can apply for an *Arbeitserlaubnis* which allows them unrestricted access to employment within a region (*Bundesland*) of Austria. Finally, in general after five years of employment, or for second generation immigrants at completion of compulsory schooling, immigrants receive a permanent work permit (*Befreiungsschein*) that allows them unrestricted access to the labor market, as well as allowing their family to join them and work in Austria. Major changes in legislation occurred in 1997 (reducing immigration quotas, especially for family members) and in 2005. Quotas are decided upon by the Ministry for Industry and Labor (*BMWA*) and implemented by the Austrian Employment Service (*AMS*). Since 1994 nationals EU-15 countries have unrestricted access to the Austrian labor market. In 2000, for example, 146,774 new work permits were issues, of which 78,008 were temporary (of which 38,589 were for seasonal work), 10,349 received an *Arbeitserlaubnis* and 44,369 were permanent work permits.[9]

The fraction foreign in total employment increases rapidly in all industries over this period, 1986 to 2004, from 5.8% to 12.9% in manufacturing and 4.8% to 16.1% in services. The share of the wage bill accruing to foreigners is somewhat lower since immigrants make

[8] Note that individual's nationality and not country of birth is recorded. Also nationality is available in the data only since 1997 on account of the way the Social Security Administration makes the data available. So it is not possible to directly observe an individual's nationality prior to 1997. This is a problem since throughout the 1980s and 1990s annually around 2-3% of foreigners living in Austria became Austrian citizens, according to data from the Austrian Forum for Migration Studies. Commonly foreigners can typically acquire the Austrian citizenship after having lived in Austria for 10 years, or at least 5 years if married to an Austrian citizen.

[9] Nowotny (2007)

between 15% to 20% less than natives on average. The fraction of low-skilled workers is much higher among foreigners than natives in Austria, as is the fraction employed in blue collar jobs, and the fraction female is lower. See Table 1 for more details.

#### 2.2.2 Labor Market

From 1972 onwards the Austrian labor market was characterized by a steady growth in employment. Male labor market participation rates declined in the 1970s from 85% and have since stabilized at around 80%. Meanwhile, female labor market participation steadily increased, from under 50% in the early 1970s to over 65% now. Austria has had low unemployment rates over the last 40 years; using ILO definitions unemployment was under 2% in the 1970s, 3-4% in the 1980s and somewhat over 4% since then. The unemployment rate of foreign nationals in Austria is higher than that of Austrians and increased from 5.5% in 1986 to 7.4% in 1992 and then continued trending upwards to 10% in 2004.[10] Labor market participation rates at the time of the 2001 census were 87% for men and 65% for women, somewhat higher than for Austrians. The participation rate varies substantially by country of origin and among men is lowest for those from EU and EFTA countries (78%) and among women among those from Turkey and Africa (around 56%). The informal economy accounts for less than 10% of GDP in Austria and somewhat more of employment. Immigrants probably have a somewhat higher propensity to be employed illegally than Austrians, with estimates varying from 10% to 20% of total employment.[11] The fraction of immigrants among the self-employed (who I exclude from the analysis) is 5.4% in 1988 and increases to 9.0% in 1992 and continues to increase slowly to nearly 11%, somewhat slower than the overall share of the number of immigrants.[12]

The OECD Employment Outlook (2004) ranks Austria in the middle of OECD countries in terms of employment protection, with substantially higher protection than in the US, Canada or the UK, and less protection than Germany, France, Spain or Sweden. Notice periods for continuous employment relationships, i.e. not short or fixed term contracts, for white collar workers (*Angestellte*) start at 6 weeks and increase with uninterrupted tenure at a firm. For blue collar workers notice periods are agreed at an industry level as part of the collective bargaining process. They vary from 1 day in construction, to up to 5 months for high skilled blue collar workers (*Facharbeiter*) in parts of manufac-

[10] Nowotny (2007) using the Austrian, rather than ILO, definition of unemployment. Under Austrian definitions the unemployment rate is always higher, currently around 2 percentage points, than under ILO definitions.

[11] Jandl (2007) an IOM (2005). In the early 1990s there was a form of amnesty for a lot of illegally employed foreign nationals, there has been no such amnesty since (Nowotny, 2007).

[12] Austrian Forum for Migration Research

turing.[13] Severance pay, starting at two months salary, for all workers is only available after 3 years of uninterrupted tenure at a firm and not available if the separation is due to a voluntary quit by the worker.[14]

Austria has a complex collective bargaining system covering 95% of employees in 2002. Currently around 450 separate wage agreements (*Kollektivverträge*) are reached by employer and employees representatives at the national level every year. These agreements typically specify minimum wages and minimum wage increases for employees by industry, occupation, skill level, and seniority. Agreements can be binding or merely recommended best-practice, and provide the framework within which actual wages are set. Detailed information on collective bargained minimum wages is only available for part of the economy, broadly corresponding to the manufacturing sector and for firms with 10 or more employees. In the 1980s actual wages were on average around 30% above the minimum mandated by collective bargaining, and only around 10% of employees were actually paid that minimum. Since then there has been a narrowing of this gap, and currently it is around 20%. In a number of industries there are also agreed minimum wage growth rates of actual wages; these are somewhat smaller than the increases in the minimum wage and set above the rate of inflation, but below the rate of nominal growth.[15]

# 3 Framework I: Substitution and Scale Effects

To understand the labor market impact of immigration the existing literature has focused on estimating the elasticity of substitution between types of labor. However, the elasticity of substitution is only informative about the impact of immigration on relative wages. In general the impact of a shifting the supply of immigrant labor on the wage level of native workers will depend on both the elasticity of substitution and the elasticity of product demand (both a substitution and scale effect). The existing literature has followed Card (2001) by controlling for the scale effect by including year fixed effects; however, to my knowledge, the scale effect has not been explicitly estimated. In this section I provide a model that makes explicit the role of scale and substitution effects. I also explicitly model the location decisions of native workers as a discrete choice model, from which I derive aggregate elasticities of labor supply. It is worth noting that a neglect of the role of scale

[13] The definition of a white collar worker is defined by law (Angestelltengesetz) and includes all salespersons and office workers (including secretaries and receptionists). Everyone else is a blue collar worker unless otherwise agreed, either by collective bargaining or at a firm or on an individual basis.

[14] Severance pay legislation was revised substantially for all employment relationships beginning after January 1, 2003. I describe the earlier system.

[15] Pollan (2001, 2005)

effects in thinking about demand shocks is not unique to the immigration literature. For example, the literature on the impact of trade on workers has also focused primarily on estimating elasticities of substitution and typically ignored scale effects, and hence the issue whether trade increases or decreases the level of demand for a countries workers.

## 3.1 Setup

### 3.1.1 Firms

Consider an economy with $S$ competitive industries in $R$ regions producing final goods $Y$, sold at prices $p$ and produced using a two-level nested-CES aggregation of native labor $N$, immigrant labor $I$ and capital $K$.

$$\begin{aligned} Y_{rs} &= F^{Y}\left(Q_{rs}, K_{rs}\right) \\ &= F^{Y}\left(F^{Q}\left(N_{rs}, I_{rs}\right), K_{rs}\right) \end{aligned} \tag{1}$$

with $\sigma_{in}$ as the elasticity of substitution between native and immigrant labor and $\sigma_{qk}$ as the elasticity of substitution between labor and capital. Note that as $\sigma_{in} \to \infty$ native and immigrant labor become perfect substitutes. I assume constant returns to scale at the level of each nest. Note that since each nest only contains two inputs I have implicitly assumed that all elasticities of substitution are non-negative (since factor demands are homogenous of degree zero in factor prices). Intuitively, if the wage of immigrant labor falls all else equal more immigrant labor will be employed (the own-price elasticity of factor demand is always negative), and since output is assumed constant less native labor will have to be employed. The demand function for the output of an sectors is given by

$$Y_s = c_s p_s^{-\psi_s} \tag{2}$$

### 3.1.2 Native Workers

Native workers of a certain type have a choice of industry and region within which to work, where for every worker it is possible to choose any combination of industry $s \in S$ and region $r \in R$. I assume that the utility of worker $j$ in industry $s$ and region $r$ can be expressed as

$$U_{jrs} = \ln \alpha_j + \ln \alpha_{rs} + \ln w_{jrs} + \varepsilon_{js} + \varepsilon_{jr} + \varepsilon_{jrs}$$

In what follows I suppress the $j$ subscript wherever possible. I further assume that $var(\varepsilon_s) = 0$. Thus

$$U_{rs} = \ln \alpha + \ln \alpha_{rs} + \ln w_{rs} + \varepsilon_r + \varepsilon_{rs} \tag{3}$$

where I assume that $\varepsilon_r$ and $\varepsilon_{rs}$ are independent for all industries and regions in workers' choice sets, $\varepsilon_{rs}$ is independent and identically Gumbel (Extreme Value Type I) distributed with a scale parameter $\mu^s$, and $\varepsilon_s$ is distributed so that $\max_r U_{rs}$ is Gumbel distributed with a scale parameter $\mu^r$ (where these scale parameters are inversely related to the variance of the error term).[16] Thus the workers' discrete choice problem takes the form of a two-level nested logit, where workers can be thought of as first choosing a region and then an industry to work in. This formulation of the representative worker's choice problem results in an elasticity of labor supply to an industry-region, $\phi_n$, with respect to a change in the wage given by:

$$\frac{d \ln N_{rs}}{d \ln w_{rs}} = \phi_n = \mu^s (1 - P(s|r)) + \mu^r P(s|r)(1 - P(r)) \tag{4}$$

where $P(s|r)$ is the probability that a worker in region $r$ chooses industry $s$ and $P(r)$ is the unconditional probability of a worker choosing to work in region $r$. The elasticity of labor supply contains two terms: the first pertaining to the response of workers in other industries within the same region, and the second to the response of workers from other regions to a change in the wage. The magnitude of each of these terms (and hence of the elasticity of labor supply) is inversely proportional to the variance of the error terms. Intuitively, a lower variance means that there are proportionally more workers over a given interval who respond to a marginal change in the wage. The nested logit assumption imposes the restriction that all the cross-elasticities within the same nest, i.e. within the same region across different industries, are the same. It does, however, allow the cross-elasticity across nests to differ from that within a nest. The order of the nesting implies that the elasticity of labor supply is higher across industries (with error term $\varepsilon_r$) than across regions (with error term $\varepsilon_r + \varepsilon_{rs}$).

[16] My formulation of the workers' discrete choice problem follows Ben-Akiva and Lerman (1985).

## 3.2 Effects of Immigration

The model delivers a number of important results. The effect of immigration on the wage $w_n$ and employment $N$ of native workers in an industry-region is given by

$$\frac{d\ln w_n}{d\ln I} = \frac{s_i\left(\eta - \sigma_{in}\right)}{\sigma_{in}\eta + \phi_n\left(s_i\eta + s_n\sigma_{in}\right)} \tag{5}$$

$$\frac{d\ln N}{d\ln I} = \phi_n \frac{d\ln w_n}{d\ln I} \tag{6}$$

where $\phi_n$ is the elasticity of native labor supply, $\eta$ is the elasticity of demand for labor and $s_i$ is the share of immigrant labor in total labor output. See Appendix A.1 for a derivation of the expressions for the labor supply elasticities and the inverse derived demand elasticities and Hicks (1963) and Allen (1938) for more general proofs of these results. The effect of immigration on wages and, since labor supply is upward sloping $\phi_n > 0$, on employment of natives is positive when $\eta > \sigma_{in}$. The inflow of immigrants is an increase in the labor supply of immigrant labor (for a given wage), reducing the cost of immigrant labor and hence resulting in two countervailing effects: (1) the substitution effect, where for a given level of output firms will substitute immigrant for native labor; and (2) the scale effect, for a given input ratio, the fall in the cost of native labor results in increased demand for native low-skilled labor. Note that the more substitutable immigrant and native labor are, the more likely it is that the wage effect is negative. The expression for the scale effect, assuming that the supply of capital is perfectly elastic, is

$$-\frac{d\ln Q}{d\ln w_q} = \eta = s_q\psi + s_k\sigma_{qk} \tag{7}$$

The scale effect is always positive and is increasing in the elasticity of demand for the final product $\psi$ (weighted by the share of labor in total output $s_q$) and the elasticity of substitution between labor and capital $\sigma_{qk}$ (weighted by the share of capital in total output $s_k$).

The degree to which the demand shock to native labor caused by immigration, whether positive or negative, expresses itself in a change in wages or employment depends on the elasticity of labor supply. The larger the elasticity of labor supply the more the wage effect of immigration is attenuated $\frac{d}{d\phi_n}\left(\frac{d\ln w_n}{d\ln I}\right) < 0$ and the employment effect is amplified $\frac{d}{d\phi_n}\left(\frac{d\ln N}{d\ln I}\right) > 0$.

The effect of immigration on immigrant wages is always negative

$$\frac{d\ln w_i}{d\ln I} = -\frac{\phi_n + s_n\eta + s_i\sigma_{in}}{\sigma_{in}\eta + \phi_n\left(s_i\eta + s_n\sigma_{in}\right)} < 0 \tag{8}$$

and the effect on total labor output is always positive

$$\frac{d\ln Q}{d\ln I}=\frac{s_i\eta\left(\sigma_{in}+\phi_n\right)}{\sigma_{in}\eta+\phi_n\left(s_i\eta+s_n\sigma_{in}\right)}>0 \tag{9}$$

# 4 Empirical Evidence I: Wage and Employment Effects of Immigration

The identification strategies in this paper rely on inter-regional variation in the inflow (over time) of immigrants into an industry. Below I discuss in detail the instrument I will use to deal with the potential endogeneity of the distribution of immigrants. I also check for the existence of pre-existing trends and conduct a falsification exercise. I then proceed to provide OLS and linear IV estimates of the impact of immigration on native worker displacement and wages. Finally, I show how these results can be used to estimate the parameters of the model outlined in the previous section. Using theses parameter estimates I provide estimates of the aggregate impact of immigration to Austria.

## 4.1 Instrument

The inflow of immigrants may be correlated with unobserved shocks to the demand for labor in a region. If immigrants are more likely to go to regions that are experiencing positive shocks to the demand for native and immigrant labor, then the OLS estimate of the effect of immigration on native employment and wages is upward biased. It is equally possible that immigrant inflows are affected by the availability of jobs in an industry. A plausible way in which the supply-side may matter is that declining industries may make a special effort to attract immigrant labor. For example, as described, many immigrants require a work permit to legally work in Austria; one way that declining industries may respond is by exerting political pressure that more work permits be issued for immigrants working in their industry. In that instance there is a negative correlation between the inflow of immigrants and shocks to the wages and employment of native labor and the OLS estimates would be downward biased.[17] The possibility of biased OLS estimates makes it important to instrument for the inflow of immigrants to an industry-region.

I instrument for the distribution of the inflow of immigrants using the pattern of foreign employment in the 1970s. The underlying idea is that one of the primary determinants of an immigrants' destination choice is a social network that helps them settle in a foreign

[17] This is what Friedberg (2001) finds when examing the distribution of Russian arrivals in Israel after the end of the Cold War.

country, as well as helping them find a job (see Card (2001), Card and Lewis (2007) and Cortes (2008) for how this instrument works for the US). I use a long baseline period, 1972 to 1979, so as to minimize the effect of short-term employment fluctuations and measurement error, which given that the number of foreigners in some industry-region cells is small could lead to a weak first stage. The social networks justification for the use of this instrument suggests that I distinguish between foreigners by nationality. Sample size considerations lead me to put foreigners in Austria into six categories: former Yugoslavia, Turkey, Eastern Europe, developed countries, Germany and Switzerland (since nationals of those two countries are likely to speak German), and immigrants from the rest of the world.

Formally, the instruments for the inflow of immigrants to a certain 2-digit industry $s$ and region $r$ at time $t$ are given by

$$\Delta foreigners_{rst}(IV) = \sum_{nationality} \frac{nationality_{rs,72-9}}{nationality_{s,72-9}} * \Delta nationality_{st} \tag{10}$$

The first stage is highly significant in all industries, apart from Food and Accommodation, and correlation coefficient between the actual and instrumented inflow of immigrant labor to an industry-region averaged over the period 1986 to 2004 is 0.5 (see Table 2).

## 4.2 Pre-Existing Trends and Falsification

For the instrument to be valid it has to be uncorrelated with other unobserved factors that may affect native (and immigrant) labor market outcomes during the period 1986 to 2004. All the main specifications in this paper are in growth rates and control for 2-digit industry by year effects, so much of the identification comes from the within 2-digit industry across regions variation in immigration flows. Hence, the biggest threat to the validity of the instrument is that there are long-term region specific trends in the growth rate of native employment or native wages that are correlated with the fraction of immigrants in that region (within each industry). Fortunately, the data lends itself to subjecting the instrument to a falsification exercise. During the period 1980 to 1985 there is near to no net immigration to Austria (see Figure 1) or any particular 1-digit industry. Hence, it is possible to test whether during this period the historical distribution of immigrants (and hence the instrument) is correlated with native labor market outcomes in this pre-period. The results suggests that the instrument is correlated with region-specific trends in native employment in manufacturing, see Table 3. This correlation is negative in all 1-digit industries, foreigners seem to be disproportionately employed in regions where an industry is in decline. This means that the instrumental variable estimates of the impact of immigration on native wages and employment may be downward biased on account of long-term demand trends. To deal with the potential bias arising from long-term region-specific trends I include region by 1-digit industry fixed effects in all subsequent specifications.

### 4.3 Immigration, Wages and Employment

The model of the previous section assumes that there is an exogenous shock to the supply of immigrants. Instrumenting for the inflow of immigrants is meant to ensure exogeneity, however, it remains to be shown that immigration can be thought of as a shock to the supply of immigrant labor. If that is true then the wages of immigrants should fall in response to an inflow of new immigrants, which in practice does not have to be true. For example, LaLonde and Topel, 1991, find that new immigrants affect cohorts of previous immigrants differentially and so the average effect of immigration on immigrant wages could be positive, in which case the model of the previous section is clearly misspecified. I regress the (instrumented) inflow of immigrants ($\Delta \ln I$) into an industry-region ($rs$) in a given year ($t$) on the change in wages of foreign nationals ($\Delta \ln w_{i,rst}$)

$$\Delta \ln w_{i,rst} = \beta_1 \Delta \ln I_{rst} + \delta_{st} + \delta_r + \varepsilon_{1,rst} \tag{11}$$

The specification includes 2-digit industry by year fixed effects ($\delta_{st}$) and region fixed effects ($\delta_r$). My main specifications are regressions of log changes on log changes since these best correspond to the theory in the previous section. In all specifications observations are weighted by employment in each industry-region cell. Identification of the effect of immigration is from the within 2-digit industry variation in immigration flows across regions, pooled over years and conditional on region-specific long-term trends. No other covariates are included. Reassuringly in all 1-digit industries both the OLS and IV estimates are negative (see Table 4). The IV estimates suggest an elasticity of immigrant wages to immigration flows of -0.22 in manufacturing and -0.09 in the service industry.

I proceed to estimate the impact of immigration on native employment growth ($\Delta \ln N$) and native wage growth ($\Delta \ln w_n$)

$$\Delta \ln N_{rst} = \beta_2 \Delta \ln I_{rst} + \delta_{st} + \delta_r + \varepsilon_{1,rst} \tag{12}$$

$$\Delta \ln w_{n,rst} = \beta_3 \Delta \ln I_{rst} + \delta_{st} + \delta_r + \varepsilon_{2,rst} \tag{13}$$

I present the results, pooled by 1-digit industry, in Table 5. In the data (OLS estimates) immigration is positively correlated with native employment growth, suggesting that there are common reasons why immigrants and natives move to a certain industry-region. However, the correlation with wages is not uniformly positive, suggesting that the data is generated by a combination of shocks to both demand and supply (hence wage and employment changes are uncorrelated). To disentangle the causal effect of immigration from this data I instrument immigration flows with the instrument described above, see equation (10).

The estimates reveal that the effect of immigration is highly heterogeneous across industries. Notably, the estimates suggest that immigration is a positive demand shock for native labor in manufacturing, the point estimates of the elasticity of native employment with respect to immigration at the industry-region level is 0.15. The wage effects of immigration in manufacturing are near zero. However, immigration can be thought of as a negative demand shock for native labor in the service industries (defined as trade services, food and accommodation and business services), with an elasticity of -0.069 for employment and -0.023 for wages (though the wage effect is not statistically significant). Since on average the fraction of immigrants in total employment is around 11% in manufacturing and 12% in services, the estimated elasticities translate into large changes in native employment. An exogenous inflow of one immigrant results in the employment of nearly 1.4 additional native worker in manufacturing. In contrast, in services an additional immigrant displaces 0.58 native workers.

Since the magnitude of the effect of immigration on native wages is small we can conclude that the elasticity of labor supply across industry-regions is high. The point estimates suggest that on average the elasticity of labor supply is substantially larger in manufacturing (around 19) than in services (around 3). The magnitude of the elasticity of labor supply will depend on the level of aggregation at which the impact of immigration is measured (in my case a 2-digit industry in a region), the length of time over which the impact is measured (in my case a single year) and institutional features, such as centralized wage-bargaining, that constrains wage-setting behavior. An important consequence of the high elasticity of labor supply is that the sign of the demand shock (positive or negative) to native labor due to immigration is more easily discernible in the data on employment than in wages. Further, if the effect of immigration and the elasticity of labor supply are both heterogenous it is difficult to interpret estimates at an aggregate level. That may, for example, explain why the effects of immigration on wages and employment in business services, which is a highly heterogeneous industry, go in the opposite direction. Institutional features, both wage-bargaining and immigration, laws why immigrant labor supply is less elastic than that of natives.

The differences between the OLS and IV estimates provides evidence on the factors that determine the location decisions of immigrants. Notice that the bias in the OLS estimates is not uniform across industries. In services the OLS estimates are consistently more positive than IV estimates, which means that demand shocks are an important determinant of immigrant location decisions $E[I_{rst}\varepsilon_{rst}] > 0$. In manufacturing the OLS estimates are barely biased, $E[I_{rst}\varepsilon_{rst}] \simeq 0$, and demand and supply shocks seem to offset each other when it comes to determining immigrant location decisions. Similarly, the OLS estimates of the impact of immigration on immigrant wages are less negative than the IV estimates,which suggests that immigrant location decisions respond to demand shocks and/or that the type of immigrant affected by the instrument has a more detrimental effect on the wage of existing immigrants than those the average immigrant. To check whether long-run region specific trends in demand are important I also run the same regressions without region-specific fixed effects. The point estimates are not substantially affected by the exclusion of region fixed effects, see Table 6.

Throughout this paper I am thinking of changes in (instrumented) immigration flows as shocks to the supply of immigrant labor, and hence as shocks to the demand for other types of (native) labor. This approach differs somewhat from the dominant approaches in the literature, as exemplified by Card (2001) and Borjas (2003), which view immigration as shocks to factor proportions, as measured by education or experience. The main reason for doing so is practical, my data on worker education and foreign worker experience is limited, and so it does not seem sensible to rely on an approach that emphasizes changes in factor proportions. Recall that the education categories I use do not correspond to those used in the US since Austria's education system is very different. Moreover, there are a number of reasons, including measurement error, why workers across education groups are more similar than we might wish. Nevertheless, it is surprising that the effect of immigration on the wages and employment of low-skilled natives is very similar to that of higher-skilled natives (see Table 7). It seems as though in Austria educational attainment, at least the way I am able to measure it, is not a very salient feature for understanding wage differentials (see Blau and Kahn, 1996, and Leuven, Oosterbeek and van Ophem, 2004 for further discussion of this issue for countries other than the US). For this reason I will not differentiate between natives by education in the remainder of this paper, though all the models in this paper are easily extended to allow for differential effects by education. Similarly, the instrumental variable estimates do not show a statistically significant differential impact of immigration on male versus female native workers. There is some evidence though that blue collar workers do better than white collar workers, which is surprising since immigrants are predominantly blue collar. What is striking is that throughout the OLS estimates suggest that immigration is positively correlated with the relative outcomes of the factors which immigrants disproportionately bring to the labor market, that is low skilled, male and blue collar as compared to high skilled, female and white collar. This suggests that the distribution of immigrant flows responds to differential factor returns rather than vice-versa.

An advantage of the instrumental variable approach (over a more structural approach for example) is that it helps deal with measurement problems. For example, there are large numbers of illegally employed, and hence unobserved, immigrant and native workers resulting in both attenuation bias (if illegal and legal immigration flows are uncorrelated) and more complicated biases (if they are correlated) in the OLS estimates. Similarly, the educational attainment and experience of immigrants is not likely to be constant within an industry-year causing biased OLS estimates. But for the instrumental variable estimates it is only necessary that these compositional effects are uncorrelated with the initial distribution of immigrants.

There are however a number of other confounding factors that bias the estimates of the employment and wage effects of immigration. First, I am assuming that immigration causes native workers to change employers solely on account of changes in the wage. However, there may be non-pecuniary reasons why natives may or may not wish to work with immigrants. If, for example, natives have a distaste for working with immigrants then the estimate of the impact of immigration on native employment is biased downward. This is because, as well as changing the demand for native labor, immigration also reduces the supply of native labor for a given wage.

Further, immigration to an industry-region may, for example, significantly increase the demand for the output of that industry-region, which would result in an upward bias of the estimates (specifically, the estimated elasticity of product demand will be upward biased, since I would be confusing shifts in demand with the elasticity of demand). However, even if workers spend all of their income in the same region (recall that the returns to capital can accrue to investors from all over the world) only a very small fraction would be ultimately be spent on the output of the industry they are actually employed in, so this bias is likely to be small. Similarly, if the supply of other factors of production such as capital and land were upward-sloping, as opposed to perfectly elastically supplied as I assume, then my estimate of the elasticity of product demand would be upward biased (though the estimate of the elasticity of labor demand would, given the weak separability assumption, be unbiased).

Also, immigration may cause changes in both the "quality" of native workers, as well as the quantity. If immigrants were better substitutes for low than high ability (as measured by units of human capital) natives then I would be overestimating the wage and underestimating the employment effects of immigration. This is a concern that can potentially be addressed using the panel aspect of the data. Finally, the IV estimates only measure the impact of those immigrants whose location decision is affected by the presence of previous cohorts of immigrants, which may be different from the impact of an average immigrant.

## 4.4 Estimating Framework I

### 4.4.1 Identification

The share of the total wage bill that goes to native and immigrant labor, $s_n$ and $s_i$ respectively, is observed directly in the data. On average over the period 1986 to 2004 the share of immigrant is labor 9.7% in manufacturing and 10.3% in services. It is somewhat less than the average number of immigrants as a fraction of the workforce (which is 11.2% in manufacturing and 12.2% in services) since on average wages of immigrants are 16.1% and 18.5% lower than that of natives in manufacturing and services respectively. I use data from Eurostat to obtain measures of the shares of labor ($s_l$) and capital ($s_k$) in total output. Further, I restrict all the elasticities of native labor supply to be the same across industry-regions. That leaves four unknown parameters $\phi_n, \psi, \sigma_{in}$ and $\sigma_{qk}$. There are three linearly independent estimating equations I estimated above, $\frac{d\ln w_n}{d\ln I}$, $\frac{d\ln N}{d\ln I}$ and $\frac{d\ln w_i}{d\ln I}$. Finally, in the absence of good data on labor shares in total output I simply assume that $\sigma_{qk} = 1$ (Cobb-Douglas), which also implies that $s_q$ and $s_k$ are constant over time (or at least uncorrelated with shocks to the supply of immigrants), thus the system is identified.

The inclusion of industry by region fixed effects means that the estimates of the previous section are (at least theoretically) unbiased. Hence, the reduced form estimates can be used to derive the structural parameters of the derived demand elasticities. The advantage of this approach is that it is clear what variation identifies which parameter. I feel that this advantage outweighs any potential loss in efficiency.

I estimate the structural parameters as follows. The labor supply elasticity is simply the effect of immigration on native employment divide by the effect on native wages, see regressions (12) and (13).

$$\phi_n = \frac{d\ln N}{d\ln I} / \frac{d\ln w_n}{d\ln I} = \beta_2/\beta_3$$

The elasticity of substitution between native and immigrant $\sigma_{in}$ labor is

$$\sigma_{in} = \frac{d\ln(I/N)}{d\ln(w_n/w_i)} = \frac{1-\beta_2}{\beta_3-\beta_2}$$

(from regressions (12), (13) and (11)). Finally, I use the expression for $\frac{d\ln Q}{d\ln I}$ and equation (7) to find the elasticity of labor $\eta$ and product demand.$\psi$

$$\begin{aligned}\eta &= \frac{\phi_n\sigma_{in}\left(s_i+s_n\frac{d\ln N}{d\ln I}\right)}{s_i\phi_n\left(1-\frac{d\ln N}{d\ln I}\right)-\sigma_{in}\frac{d\ln N}{d\ln I}} \\ \psi &= \frac{\eta-s_k\sigma_{qk}}{s_q}\end{aligned}$$

The strategy described relies on the assumption that the elasticity of labor supply is identical across industry-regions and over time. Maintaining that assumption and using the average $P(s|r)$ and $P(r)$ as observed in the data, it is possible to identify the scale parameters of the native workers' discrete choice problem ($\mu^s$ and $\mu^r$). To identify these I use the expression for the ratio of new hires to an industry-region that originate in the same region $H(s'|r)$ and from other regions $H(r')$ (using equations (33) and (34) in Appendix A)

$$\frac{H(s'|r)}{H(r')} = \frac{\mu^s(1-P(s|r))}{\mu^r(1-P(r))} - (1-P(s|r)) \tag{14}$$

### 4.4.2 Parameter Estimates

The parameter estimates for manufacturing, the service sector and across all industries are summarized in Table 9. As should be expected in both manufacturing and services immigration to an industry-region results in a fall in the average cost of labor and hence, as the price of output falls, an increase in total employment (as compared to an industry-region with no immigration). It also results in a fall in the relative wage of immigrant to native labor and an increase in the relative employment of immigrant labor.

The estimated elasticity of substitution between native and immigrant labor is considerably higher in services than in manufacturing, 16 and 4 respectively. Note that since the elasticities of substitution are larger than one immigration increase the share of immigrants in the total wage bill. The estimates suggest that industry-regions in manufacturing face highly elastic product demand, with a point estimate of the elasticity of product demand of 34 (or an elasticity of demand for labor of 17). Hence, in manufacturing the scale effect more than offsets the substitution effect and immigration results in an increase in the demand for native workers. This results in an increase in native employment in manufacturing, but due to a high elasticity of labor supply, not to an increase in the relative wage in an industry-region. In the service sector, in constrast, I find that the elasticity of product demand is inelastic (a point estimate of 1.5). As a consequence there is only a small scale effect and immigration results in a decrease in the demand for native labor. As in manufacturing this results primarily in a change in the employment, as opposed to wages, of native workers.

### 4.4.3 Aggregate Implications

The estimated elasticities are short-run elasticities at the level of an individual industry-region. In practice we are, however, primarily interested in the aggregate impact of immigration to a country (not just to a single industry-region), which we are now in position to do. Immigration results in a shift of native workers from service industries, where they are being displaced by immigrants to, manufacturing industries. On average manufacturing accounts for 19.6% of employment in the sample, and service industries 63.1% (with construction and agriculture making up the remainder). The estimates imply that a tripling of the number of immigrants in all industries due to exogenous reasons, i.e. reasons uncorrelated with the labor market outcomes of natives, would result in 7.6% of native workers in service industries to leave their job and a 18% increase in native employment in manufacturing. The impact of immigration on average native wages in Austria can be estimated by assuming that in aggregate the elasticity of labor supply is zero, i.e. that participation rates and unemployment rates are invariant with respect to immigration. Given this assumption and using equation (5) I find that the aggregate impact of having tripled the number of immigrants from 1988 to 2004 was a fall in average native wages of 4.7%.

## 5 Framework II: Endogenous Task Choice

Up to now I have been assuming that, in essence, all native workers are identical and immigration only has a differential impact on them to the extent that they work in different industries. Given the high degree of inter-industry labor mobility I am unable to address the issue of the impact of immigration on wage inequality. Moreover, I have maintained the assumption that native workers can only respond to immigration by changing industry. However, work by Autor, Levy and Murnane (2003) suggests that workers respond to (technology) shocks by changing the type of tasks they are engaged in. Cortes (2006) and Peri and Sparber (2007) apply this idea to the effects of immigration. Using US data they find evidence in favor of native task specialization in response to immigration. In this section I extend my basic framework to allow for endogenous task choice by native workers and derive explicit expressions for the elasticities of derived demand in a model with task specialization

## 5.1 Setup

### 5.1.1 Firms

Consider an economy with a large number $S$ of small competitive industries in $R$ regions producing final goods $Y_{rs}$, sold at prices $p_s$ and produced using a two-level nested CES-aggregation of manual tasks $M$, interactive tasks $X$ and capital $K$.

$$\begin{aligned} Y_{rs} &= F^Y\left(Q_{rs}, K_{rs}\right) \\ &= F^Y\left(F^Q\left(M_{rs}, X_{rs}\right), K_{rs}\right) \end{aligned} \tag{15}$$

$\sigma_{mx}$ is the elasticity of substitution between manual and interactive skills and $\sigma_{qk}$ is the elasticity of substitution between labor and capital. The inverse demand function for the output of a sector is the same as in the previous model, see equation (2). The derivation of all results in this section are in Appendix B.

### 5.1.2 Native Workers

Native workers, as before, have a choice of industry and region within which to work. In addition, they have a choice of task $\tau$, manual $m$ or interactive $x$. For every worker it is possible to choose any combination of industry $s \in S$ , region $r \in R$ and task $\tau \in \{m, x\}$ within which to work. I assume that the utility of worker $j$ in industry $s$, region $r$ and task $\tau$ can be expressed as

$$U_{jrs\tau} = \ln\alpha_j + \ln\alpha_{rs\tau} + \ln w_{jrs\tau} + \varepsilon_{js} + \varepsilon_{jr} + \varepsilon_{j\tau} + \varepsilon_{jrs} + \varepsilon_{jr\tau} + \varepsilon_{js\tau} + \varepsilon_{jrs\tau}, \quad \forall j \in N_L$$

In what follows I suppress the $j$ subscript wherever possible. I further assume that $var\left(\varepsilon_\tau\right) = var\left(\varepsilon_{\tau s}\right) = var\left(\varepsilon_{r\tau}\right) = 0$ and $var\left(\varepsilon_s\right) = 0$. Thus

$$U_{rs\tau} = \ln\alpha + \ln\alpha_{rs\tau} + \ln w_{rs\tau} + \varepsilon_r + \varepsilon_{rs} + \varepsilon_{rs\tau} \tag{16}$$

where I assume that $\varepsilon_\tau$, $\varepsilon_{s\tau}$ and $\varepsilon_{rs\tau}$ are independent for all industries, regions and tasks in workers' choice sets, $\varepsilon_{rs\tau}$ is independent and identically Gumbel (Extreme Value Type I) distributed with a scale parameter $\mu^\tau$, the scale of $\varepsilon_{rs} + \varepsilon_{rs\tau}$ is denoted by $\mu^s$ and the scale of $\varepsilon_r + \varepsilon_{rs} + \varepsilon_{rs\tau}$ by $\mu^r$. This three-level nested formulation is equivalent to native workers first choosing a region, then an industry and finally a task to work in. The own-wage elasticity of labor supply to a certain task in an industry-region is

$$\phi_\tau^\tau = \mu^\tau \left(1 - P\left(\tau|r,s\right)\right) + \mu^s \left(1 - P\left(s|r\right)\right) P\left(\tau|r,s\right) + \mu^r \left(1 - P\left(r\right)\right) P\left(\tau|r,s\right) P\left(s|r\right), \quad \tau = (m,x) \tag{17}$$

where $P(\tau|r,s)$ is the conditional probability a worker chooses a certain task given a choice of industry-region, $P(s|r)$ is the probability of choosing an industry given a choice of region and $P(r)$ the unconditional probability of choosing a certain region. The elasticity of labor supply has three components corresponding to the response of workers within the same industry-region, the same region and different regions respectively. Also note that the elasticity of labor supply to a task from workers outside an industry-region is equal to

$$\phi_\tau^\tau + \phi_{\tau'}^\tau = \mu^s \left(1 - P\left(s|r\right)\right) P\left(\tau|r,s\right) + \mu^r \left(1 - P\left(r\right)\right) P\left(\tau|r,s\right) P\left(s|r\right), \quad \tau \neq \tau', \tau = (m,x) \tag{18}$$

where $\phi_x^m = \frac{d \ln M}{d \ln w_x}$ and $\phi_m^x = \frac{d \ln X}{d \ln w_m}$.

## 5.2 Effects of Immigration

To analyze the impact of immigration on native labor market outcomes I assume that low-skilled immigrants have a comparative advantage in manual tasks. Specifically, I assume that all immigrants provide manual tasks. I also assume that immigrants are perfect substitutes for natives carrying out manual tasks. In essence "manual" tasks are simply those tasks for which natives and immigrants are perfect substitutes. This assumption will be crucial to my identification strategy as it allows me to use the (instrumented) inflow of immigrants as a proxy for a shock to the supply of manual tasks in an industry-region.

The total quantity of manual labor in an industry consists of native and immigrant workers, $M_N$ and $I$ respectively. An arrival of immigrants will always increase the total quantity of manual tasks provided in an industry

$$\frac{d \ln M}{d \ln I} = \frac{s_i}{1 + s_n \left(\phi_m^m \left(-\frac{d \ln w_m}{d \ln M}\right) - \phi_x^m \frac{d \ln w_x}{d \ln M}\right)} > 0 \tag{19}$$

where $s_i$ and $s_n$ are, respectively, the shares of immigrant and native workers engaged in manual labor and $-\frac{d\ln w_m}{d\ln M} > 0$ and $\phi_x^m < 0$. The demand for each task is downward sloping, and so immigration will always decrease the wage of workers engaged in manual tasks

$$\frac{d\ln w_m}{d\ln M} = -\frac{s_m\sigma_{xm} + s_x\eta + \phi_x^x}{\eta\sigma_{xm} + \phi_x^x\left(s_m\eta + s_x\sigma_{xm}\right) - s_x\phi_m^x\left(\eta - \sigma_{xm}\right)} < 0 \tag{20}$$

where $s_m$ and $s_x$ are the shares of manual and interactive labor in total labor output.

The effect on wages of native workers engaged in interactive tasks is more complicated. There is both a scale effect, for a given factor ratio the cost of production falls and output expands, thereby increasing the demand for all factors; and a substitution effect, for a given level of output, there is substitution from interactive to manual tasks as the relative wage changes.

$$\frac{d\ln w_x}{d\ln M} = \frac{s_m\left(\eta - \sigma_{xm}\right) + \phi_m^x}{\eta\sigma_{xm} + \phi_x^x\left(s_m\eta + s_x\sigma_{xm}\right) - s_x\phi_m^x\left(\eta - \sigma_{xm}\right)} \tag{21}$$

If $\eta > \sigma_{xm}$ then immigrant will increase the wage of workers engaged in interactive tasks. Note if $\phi_m^x = 0$, i.e. if there is no endogenous task choice, then these expressions simplify to the well-known derived demand elasticities of the previous section. Also note that since $\phi_m^x < 0$ the inverse derived demand elasticities are attenuated as compared to those without endogenous task choice (as long as $\eta > \sigma_{xm}$). The intuition for this result is that labor to each task is more elastically supplied if task choice is endogenous (as opposed to when it is not). As a consequence the response of task wages to an inflow of immigrants is attenuated on account of workers switching tasks within an industry (equivalently the elasticity of derived demand increases, i.e. the quantity response to a given shock in wages is higher). Similarly, while employment in a given task becomes more responsive to immigration, the effect on total employment is an industry-region is reduced, since some workers will now switch tasks instead of leaving the industry-region entirely.

As before immigration always has a positive effect on total labor output, $\frac{d\ln Q}{d\ln M} > 0$, see equation (40) in Appendix B.

While it is possible for both interactive and manual wages to fall the relative wage of interactive versus manual tasks in an industry-region will always increase

$$\frac{d}{d\ln M}\ln\left(\frac{w_x}{w_m}\right) = \frac{\eta + \left(\phi_m^x + \phi_x^x\right)}{\eta\sigma_{xm} + \phi_x^x\left(s_m\eta + s_x\sigma_{xm}\right) - s_x\phi_m^x\left(\eta - \sigma_{xm}\right)} > 0 \tag{22}$$

and so there will always be a fraction of low-skilled native workers who were previously engaged in manual tasks who will switch to carrying out interactive tasks in the same industry.

The total effect on the number of native skilled workers due to an increase in the amount of manual labor in an industry-region, which is also the elasticity of labor supply to an industry-region (for a given relative wage within that industry-region), is given by

$$\frac{d\ln(X+M_N)}{d\ln M}=(\phi_x^x+\phi_m^x)\frac{X}{X+M_N}\frac{d\ln w_x}{d\ln M}+(\phi_m^m+\phi_x^m)\frac{M_N}{X+M_N}\frac{d\ln w_m}{d\ln M} \quad (23)$$

Finally, the effect on the ratio of interactive to manual tasks among natives is

$$\frac{d\ln(X/M_N)}{d\ln M}=(\phi_x^x-\phi_x^m)\frac{d\ln w_x}{d\ln M}+(\phi_m^x-\phi_m^m)\frac{d\ln w_m}{d\ln M}>0 \quad (24)$$

which is always positive. The effect on total labor output is also always positive

$$\frac{d\ln Q}{d\ln M}=\frac{s_m\psi(\sigma_{xm}+\phi_x^x)-s_x\psi\phi_m^x}{\psi\sigma_{xm}+\phi_x^x(s_m\psi+s_x\sigma_{xm})-s_x\phi_m^x(\psi-\sigma_{xm})}$$

# 6 Empirical Evidence II: The Impact of Immigration on Task Specialization and Inequality

If workers' choice of tasks is observed in the data estimating this model is not much more complicated than estimating a model without endogenous task choice. However, in the data available to me I do not observe the tasks that workers are engaged in. This obviously makes estimating this model considerably more complicated. Nevertheless, it turns out to be possible if we are willing to take the model quite literally. The key assumptions I will be making are that (1) all immigrants engage in manual labor (although this assumption can be relaxed), (2) immigrants and natives are perfect substitutes when engaged in manual tasks. These assumptions immediately imply that the wage for natives engaged in manual tasks is the same as that for immigrants. Moreover, any new native workers who join an industry-region in response to an inflow of immigrant workers must be engaged in interactive tasks; and any workers who leave an industry-region due to immigration must have been providing manual tasks. Consequently, these new hires experience the wage gains associated with the increase in the wage for interactive task. Incumbent workers, in contrast, experience a weighted average of the change in the wage due to immigration in both tasks.

In this section, using the fact that I have individual level panel data, I provide evidence on the impact of immigration on hire and separation rates, as well as associated wage changes. I then show how these can be used to estimate the parameters of the model with endogenous task choice and what they imply for the impact of immigration on task specialization and inequality.

## 6.1 Immigration, Hire and Separation Rates

By definition the net changes in native employment $\Delta \ln N_{rst}$ in an industry-region is the difference between new hires $H_{rst}$ and separations $S_{rst}$:

$$\Delta \ln N_{rst} \approx \frac{N_{rst} - N_{rs(t-1)}}{\left(N_{rst} + N_{rs(t-1)}\right)/2} = \frac{H_{rst}}{\left(N_{rst} + N_{rs(t-1)}\right)/2} - \frac{S_{rst}}{\left(N_{rst} + N_{rs(t-1)}\right)/2}$$

On average annually around 30% of all workers are new hires to an industry-region. Turnover is somewhat lower in manufacturing, with new hires accounting for 25% of employees in an industry-region. In services the number of new hires in total employment varies between 28% in retail and wholesale trade, 32% in food and accommodation and 36% in business services. In all industries around two-thirds of all new hires are hired from within the same region, and one-third previously worked in a different region.

I study the effect of immigration on the hire and separation rate using the following specifications

$$\frac{H_{rst}}{\left(N_{rst} + N_{rs(t-1)}\right)/2} = \beta_4 \Delta \ln I_{rst} + \delta_{st} + \delta_r + \varepsilon_{4,rst} \quad (25)$$

$$\frac{S_{rst}}{\left(N_{rst} + N_{rs(t-1)}\right)/2} = \beta_5 \Delta \ln I_{rst} + \delta_{st} + \delta_r + \varepsilon_{5,rst} \quad (26)$$

I also look at the associated changes in wages by looking at the effect of immigration on the wages of native new hires $w_{n|H}$ and native incumbent workers $w_{n|H'}$ (i.e. a currently employed worker who is not a new hire)

$$\Delta \ln w_{n|H,rst} = \beta_6 \Delta \ln I_{rst} + \delta_{st} + \delta_r + \varepsilon_{6,rst} \quad (27)$$

$$\Delta \ln w_{n|H',rst} = \beta_7 \Delta \ln I_{rst} + \delta_{st} + \delta_r + \varepsilon_{7,rst} \quad (28)$$

The results are summarized in Tables 9. In manufacturing there is an increase in native employment due to an increase in the hire rate of new workers and a fall in the separation rate. The elasticity of the hire rate with respect to immigration is 0.1, while the elasticity of the separation rate is -0.55. In services, in contrast, the decrease in native employment due to immigration can be accounted for by a fall in the hire rate (with an elasticity of -0.04) and increase in the separation rate (with an elasticity of 0.03). Unfortunately, the model, since it predicts that immigration should always increase separation rates, it does not capture this aspect of the data very well.

The IV estimates of the elasticity of wages for new hires with respect to immigration is 0.04 in manufacturing. However, the wages of incumbent workers, those who stay in the industry-region despite the inflow of immigrants, are on average unaffected by immigration. Wages for new hires are unchanged, while wages for incumbent workers in the service sector fall, with an elasticity of -0.02 with respect to immigration. What all industries have in common is that immigration has a more positive impact on the wage of new hires than it does on the wages of incumbent workers. Unfortunately, none of the wage estimates are statistically significant, but at least the point estimates are consistent with the model of endogenous task choice.

## 6.2 Estimating Framework II: Identification and Results

I will be assuming that (1) all immigrants engage in manual labor, and (2) immigrants and natives are perfect substitutes when engaged in manual tasks. Also, as previously, I assume that labor and capital are combined using a Cobb-Douglas production function $\sigma_{qk}$. My estimation procedure again relies on the linear IV estimates from regressions (12) to (28).

Since immigrants and natives are perfect substitutes in the provision of manual tasks the impact of immigration on manual wages is the same as the impact of immigration on immigrant wages, i.e. $\frac{d\ln w_m}{d\ln I} = \frac{d\ln w_i}{d\ln I}$. Any additional hires to the industry-region due to immigration must be engaged in interactive tasks (since manual wages always fall due to immigration there will be a net outflow of workers from manual tasks). Hence, any increase in wages of new hires caused by immigration must reflect a change in the wage of interactive tasks $\frac{d\ln w_x}{d\ln I} = \frac{d\ln w_{n|H,rst}}{d\ln I}$. Further, the change in the average native wage in an industry-region, ignoring second-order effects, is

$$s_x \frac{d\ln w_x}{d\ln I} + s_m s_n \frac{d\ln w_m}{d\ln I} = \frac{d\ln w_n}{d\ln I}$$

,which combined with knowledge of the wage for manual tasks $w_m$ (which is simply the average wage of immigrants), the total employment of natives in the industry $(X + M_N)$ and total income for natives in that industry $(w_x X + w_m M_N)$ can be used to find $X, M, s_m, s_n, s_i, s_x$ and $w_x$.

The effect on total native employment, given by equation (23), can be used to derive

$\phi_x^x + \phi_m^x = \phi_m^m + \phi_x^m = \phi_n$. Since from equation () we know that

$$\frac{d\ln\left(X/M_N\right)}{d\ln I} = \left(\phi_x^x + \phi_m^x\right)\frac{d\ln w_x}{d\ln I} - \left(\phi_m^m + \phi_x^m\right)\frac{d\ln w_m}{d\ln I}$$

we can estimate $\frac{d\ln(X/M_N)}{d\ln I}$ and thus $\sigma_{mx}$.

This estimation procedure is not as neat as that for the previous model. However, intuitively, the reason it works is that despite the labor inputs being unobserved we do observe the changes in wages to manual and interactive labor (given the assumptions of the model). We can also indirectly infer the elasticities of labor supply by the differential response to immigration of wages of incumbents and new hires, as well as the total change in native employment due to immigration. This estimation procedure is clearly only feasible due to the availability of panel data.

While the results seem broadly consistent with the model the lack of significant estimates for anything but the impact of immigration on hire rates is clearly unsatisfactory. Hence, instead of estimating all the parameters of the model I simply estimate the implied changes in the fraction of natives employed in the two factors of production (tasks), as well as associated wage changes. The fraction of natives engaged in manual tasks, i.e. types of activities where immigrants are perfect substitutes for natives is around 36% in services and 16% in manufacturing. Over the period 1986 to 2004 the tripling of the number of immigrants caused this fraction to fall from 45% to 34% in services and 19% to 13% in manufacturing. This shift in the factor that natives supply to an industry is due to the impact immigration has on the relative wages accruing to the two factors. The implication is that the relative wage paid to those supplying the immigrant intensive task falls by 2% in services and 4.5% in manufacturing. This suggests that immigration does increase inequality among native workers even within the same industry, however that effect is mitigated by the ability of natives to change the type of task they are engaged in.

# 7 Conclusions

There is a large literature on the impact of immigration on inequality between different types of native labor. This paper contributes to the immigration literature by estimating the impact on wage levels. The effect of immigration on inequality depends on the elasticity of substitution, which is defined for a given level of output, between types of labor. The impact on wage levels also depends on the degree to which output expands as immigration reduces the cost of production. The magnitude of this scale effect depends on the elasticity of product demand, with the effect of immigration on the demand for native labor depending on the difference in the magnitude of scale and substitution effects. An important insight of the paper is that the scale effect will vary considerably by industry, since the elasticity of product depend will vary, and so immigration is likely to have a highly heterogenous effect depending on what industry immigrants join. The more the scale of output can expand, and the lower the elasticity of substitution, the more immigration will benefit native labor. This is a broader lesson and true for the response to any type of supply shock, for example also to the impact of trade on wage levels. This insight has implications for policy, for example, for the decision what industries to issue work permits to. Further, given the evidence on the heterogeneity of scale effects across industries it would be important to identify what observable industry or worker characteristics can explain these differences. The tradeability of final output is an obvious example and there are likely to be others.

The paper also contributes to the debate on how to best empirically identify the impact of immigration. The approach the paper takes is to use an instrumental variable strategy to deal with the endogeneity of immigrant location decisions, which may result in a non-causal correlation between immigration flows and native labor outcomes. This is the approach the local labor markets literature takes and is open to the criticism that natives will decide to move across units of observation in response to immigration, thereby attenuating the measured impact of immigration. I deal with this concern by explicitly modeling the response of natives to immigration and accounting for this effect when estimating scale and substitution effects. My methodology thereby addresses the drawbacks of both the local labor markets and the time series approach, which does not allow for the instrumenting of the distribution of immigration flows, to identifying the impact of immigration. The same methodology can be applied to US data and may help resolve some of the controversy between proponents of the different methodologies.

The focus of this paper has been primarily on natives, however, an important counterpart of this work is to think more about the immigrants themselves. This would also help provide a more nuanced view of what determines the elasticity of substitution between immigrants and natives, which surely must depend on the relative characteristics of these two groups. One way to pursue this issue is by combining information on workers occupation as recorded by the Austrian Employment Service (AMS) with the social security data used in this paper. This would allow for an exploration, with the help of the framework provided in Section 5, of what types of activities immigrants and natives engage, how these interact (as measured by the elasticity of substitution) and how native occupation choices respond to immigration.

# Appendix A

In this section I derive the factor demand elasticities and elasticities of labor supply for the model in Section 4. I suppress industry and region subscripts.

## A.1 Elasticities of derived demand

Firms maximize profits subject to equations (1) and (2). Taking the derivative of the first-order conditions with respect to a change in the number of immigrants:

$$\frac{d\ln w_i}{d\ln I} = \frac{d\ln Q}{d\ln I}\left(\frac{1}{\sigma_{in}} - \frac{1}{\eta}\right) - \frac{1}{\sigma_{in}} \tag{29}$$

$$\frac{d\ln w_n}{d\ln I} - \frac{d\ln w_i}{d\ln I} = \frac{1}{\sigma_{in}}\left(1 - \frac{d\ln N}{d\ln w_n}\frac{d\ln w_n}{d\ln I}\right) \tag{30}$$

Eliminating $\frac{d\ln w_i}{d\ln I}$ using (29) and (30)

$$\frac{d\ln Q}{d\ln I} = \frac{d\ln w_n}{d\ln I}\frac{\eta\left(\sigma_{in} + \phi_n\right)}{\left(\eta - \sigma_{in}\right)} \tag{31}$$

Then I differentiate the production function and use the fact that with constant returns to scale $s_i = \frac{w_i I}{w_q Q} = \frac{w_i}{w_q}\frac{I}{Q} = \frac{F_I I}{Q}$ and $s_n = \frac{w_n N}{w_q Q} = \frac{F_N N}{w_q Q}$

$$\begin{aligned} \frac{dQ}{dI} &= F_I + F_N \frac{dN}{dw_n}\frac{dw_n}{dI} \\ \frac{d\ln Q}{d\ln I} &= s_i + s_n\phi_n \frac{d\ln w_n}{d\ln I} \end{aligned} \tag{32}$$

I eliminate $\frac{d\ln w_n}{d\ln I}$ using (31) and (32) to find the expression for $\frac{d\ln w_n}{d\ln I}$, see equation (5). Then substitute into (31) to find the expression for $\frac{d\ln Q}{d\ln I}$ (9). Finally, substituting this expression into (29) to obtain $\frac{d\ln w_i}{d\ln I}$ as a function of the exogenous parameters.

## A.2 Native worker labor supply

A worker's chooses an industry and a region in which to work following (3). Hence, the marginal probability that a worker chooses region $r$ is given by the probability that

$$P\left(r\right) = \Pr\left[\varepsilon_r + \max_s\left(\ln\alpha_{rs} + \ln w_{rs} + \varepsilon_{rs}\right) \geq \varepsilon_{r'} + \max_s\left(\ln\alpha_{r's} + \ln w_{r's} + \varepsilon_{r's}\right), \quad \forall r' \in R, r' \neq r\right]$$

Since $\varepsilon_{rs}$ is Gumbel distributed with parameter $\mu^s$ the term $\max_s (\ln \alpha_{rs} + \ln w_{rs} + \varepsilon_{rs})$ is also Gumbel distributed and can be written as $\tilde{\alpha}_r + \tilde{\varepsilon}_r$ where

$$\begin{aligned} J_r &= \left( \sum_s (\alpha_{rs} w_{rs})^{\mu^s} \right)^{1/\mu^s} \\ \tilde{\varepsilon}_r &= \max_s (\ln \alpha_{rs} + \ln w_{rs} + \varepsilon_{rs}) - \tilde{\alpha}_r \end{aligned}$$

and $\tilde{\varepsilon}_r$ is Gumbel distributed with scale parameter $\mu^s$. The combined disturbance $\varepsilon_r + \tilde{\varepsilon}_r$ is, as assumed, independent and identically Gumbel distributed with scale parameter $\mu^r$ for all $r \in R$ , therefore

$$P(r) = \frac{e^{\mu^r \ln J_r}}{\sum_{r' \in R} e^{\mu^r \ln J_{r'}}} = \frac{J_r^{\mu^r}}{\sum_{r'} J_{r'}^{\mu^r}}$$

The conditional choice probability of choosing industry $s$ having decided on region $r$ is

$$P(s|r) = \Pr\left[\ln \alpha_{rs} + \ln w_{rs} + \varepsilon_{rs} \geq \ln \alpha_{rs'} + \ln w_{rs'} + \varepsilon_{rs'}, \quad \forall s' \in S, s' \neq s | r \text{ chosen}\right]$$

The components attributable to the industry cancel, so

$$P(s|r) = \frac{e^{\mu^s \ln \alpha_{rs} w_{rs}}}{\sum_{s'} e^{\mu^s \ln a_{rs'} w_{rs'}}} = \frac{(\alpha_{rs} w_{rs})^{\mu^s}}{\sum_{s'} (a_{rs'} w_{rs'})^{\mu^s}}$$

and the joint probability is

$$P(r,s) = P(s|r) P(r) = \frac{(\alpha_{rs} w_{rs})^{\mu^s}}{\sum_{s'} (a_{rs'} w_{rs'})^{\mu^s}} \frac{J_r^{\mu^r}}{\sum_{r'} J_{r'}^{\mu^r}}$$

Assuming $\bar{N}$ homogeneous workers the labor supply to a given industry and region is $N_{rs} = \bar{N} P_\tau (r,s)$. The elasticity of the labor supply to an industry-region with respect to a change in the wage is found by taking the derivative with respect to $w_{rs}$ and is given by (4). Further, the cross-elasticity of labor supply with respect to a change in the wage of an industry in a different region is

$$\begin{aligned} \frac{d \ln P(r', s)}{d \ln w_{rs}} &= \frac{d \ln P(r')}{d \ln J_r} \frac{d \ln J_r}{d \ln w_{rs}} \\ &= -\mu^r P(r) P(s|r) = -\mu^r P(s,r) \end{aligned} \tag{33}$$

The cross-elasticity of labor supply with respect to a change in the wage of an industry in the same region is

$$\begin{aligned}\frac{d\ln P(r,s')}{d\ln w_{rs}} &= \frac{d\ln P\left(s'|r\right)}{d\ln w_{rs}} + \frac{d\ln P\left(r\right)}{d\ln J_r}\frac{d\ln J_r}{d\ln w_{rs}} \\ &= -\mu^s P\left(s|r\right) + \mu^r P\left(s|r\right)\left(1-P\left(r\right)\right) \qquad (34)\end{aligned}$$

Combining (33) and (34) yields the expression for the ratio of within region to outside of region hires (14).

# Appendix B

In this section I derive the factor demand elasticities and elasticities of labor supply for the model in Section 5. I suppress industry and region subscripts.

## B.1 Elasticities of derived demand

The model described by (15) and (2) is different from that in the previous section in that the supply of native labor to each task now depends on the wage of each task in an industry region. Taking derivatives of the first-order conditions with respect to a change in the supply of manual tasks:

$$\frac{d\ln w_m}{d\ln M} = \left(\frac{\eta-\sigma_{xm}}{\eta\sigma_{xm}}\right)\frac{d\ln Q}{d\ln M} - \frac{1}{\sigma_{xm}} \qquad (35)$$

$$\frac{d\ln w_m}{d\ln M} = \frac{\sigma_{xm}+\phi_x^x}{\sigma_{xm}-\phi_m^x}\frac{d\ln w_x}{d\ln M} - \frac{1}{\sigma_{xm}-\phi_m^x} \qquad (36)$$

and taking the derivative of the production function the respect to the supply of manual tasks:

$$\frac{d\ln Q}{d\ln M} = s_m + s_x\left(\phi_x^x\frac{d\ln w_x}{d\ln M} + \phi_m^x\frac{d\ln w_m}{d\ln M}\right) \qquad (37)$$

I eliminate $\frac{d\ln w_m}{d\ln M}$ in (35) and (36) to obtain

$$\frac{d\ln Q}{d\ln M} = \frac{\eta\left(s_m\sigma_{xm}-s_x\phi_m^x\right)}{\eta\sigma_{xm}-s_x\phi_m^x\left(\eta-\sigma_{xm}\right)} + \frac{s_x\eta\sigma_{xm}\phi_x^x}{\eta\sigma_{xm}-s_x\phi_m^x\left(\eta-\sigma_{xm}\right)}\frac{d\ln w_x}{d\ln M} \qquad (38)$$

and using (37)

$$\frac{d\ln Q}{d\ln M} = \frac{\eta\sigma_{xm}}{\left(\eta-\sigma_{xm}\right)}\frac{\sigma_{xm}+\phi_x^x}{\sigma_{xm}-\phi_m^x}\frac{d\ln w_x}{d\ln M} - \frac{\eta\phi_m^x}{\left(\eta-\sigma_{xm}\right)\left(\sigma_{xm}-\phi_m^x\right)} \qquad (39)$$

From (38) and (39) I then derive the expression for $\frac{d\ln w_x}{d\ln M}$, see equation (21) and

$$\frac{d\ln Q}{d\ln M}=\frac{s_m\eta\left(\sigma_{xm}+\phi_x^x\right)-s_x\eta\phi_m^x}{\eta\sigma_{xm}+\phi_x^x\left(s_m\eta+s_x\sigma_{xm}\right)-s_x\phi_m^x\left(\eta-\sigma_{xm}\right)} \tag{40}$$

Finally substituting (40) into (35) allows me to solve for $\frac{d\ln w_m}{d\ln M}$, see equation (20), in terms of the exogenous parameters.

## B.2 Native worker labor supply

Workers have a choice of industry, region and task as described by (16). Using the same reasoning as above one can show that the probability of a worker choosing a certain task in a certain industry-region $P(r,s,\tau)$ can be expressed as

$$\begin{aligned}
P(r,s,\tau) &= P(\tau|r,s)\,P(s|r)\,P(r)\\
P(\tau|r,s) &= \frac{\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}}{\sum_{\tau'}\left(\alpha_{rs\tau'}w_{rs\tau'}\right)^{\mu^\tau}},\quad P(s|r)=\frac{J_{rs}^{\mu^s}}{\sum_{s'}J_{rs'}^{\mu^s}},\quad P(r)=\frac{J_r^{\mu^r}}{\sum_{r'}J_{r'}^{\mu^r}}\\
J_{rs} &= \left(\sum_\tau\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}\right)^{1/\mu^\tau},\quad J_r=\left(\sum_s J_{rs}^{\mu^s}\right)^{1/\mu^s}
\end{aligned}$$

where a useful property of $J_r$ and $J_{rs}$ is

$$\frac{d\ln J_{rs}}{d\ln w_{rs\tau'}}=\frac{\left(\alpha_{rs\tau'}w_{rs\tau'}\right)^{\mu^\tau}}{\sum_\tau\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}},\quad \frac{d\ln J_r}{d\ln w_{rs\tau'}}=\frac{d\ln J_r}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau'}}=\frac{\left(\alpha_{rs\tau'}w_{rs\tau'}\right)^{\mu^\tau}}{\sum_\tau\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}}\frac{J_{rs}^{\mu^s}}{\sum_s J_{rs}^{\mu^s}}$$

The elasticity of labor supply, assuming a homogenous workers

$$\begin{aligned}
\frac{d\ln N_{rs\tau}}{d\ln w_{rs\tau}} &= \frac{d\ln P(\tau|r,s)}{d\ln w_{rs\tau}}+\frac{d\ln P(s|r)}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}}+\frac{d\ln P(r)}{d\ln J_r}\frac{d\ln J_r}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}}\\
&= \mu^\tau\left(1-\frac{\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}}{\sum_{\tau'}\left(\alpha_{rs\tau'}w_{rs\tau'}\right)^{\mu^\tau}}\right)+\mu^s\left(1-\frac{J_{rs}^{\mu^s}}{\sum_{s'}J_{rs'}^{\mu^s}}\right)\frac{\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}}{\sum_\tau\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}}\\
&\quad+\mu^r\left(1-\frac{J_r^{\mu^r}}{\sum_{r'}J_{r'}^{\mu^r}}\right)\frac{\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}}{\sum_\tau\left(\alpha_{rs\tau}w_{rs\tau}\right)^{\mu^\tau}}\frac{J_{rs}^{\mu^s}}{\sum_s J_{rs}^{\mu^s}}\\
\phi_\tau^\tau &= \mu^\tau\left(1-P(\tau|r,s)\right)+\mu^s\left(1-P(s|r)\right)P(\tau|r,s)+\mu^r\left(1-P(r)\right)P(\tau|r,s)\,P(s|r)
\end{aligned}$$

There are several different cross-wage elasticities of labor supply to a task in an industry-region. The elasticity of labor supply with respect to a change in the wage of the other task in the same industry and region.

$$\begin{aligned}
\frac{d\ln N_{rs\tau'}}{d\ln w_{rs\tau}} &= \frac{d\ln P(\tau'|r,s)}{d\ln w_{rs\tau}} + \frac{d\ln P(s|r)}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}} + \frac{d\ln P(r)}{d\ln J_r}\frac{d\ln J_r}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}} \\
&= -\mu^{\tau}\frac{(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}}{\sum_{\tau}(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}} + \mu^{s}\left(1-\frac{J_{rs}^{\mu^{s}}}{\sum_{s'}J_{rs'}^{\mu^{s}}}\right)\frac{(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}}{\sum_{\tau}(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}} \\
&\quad +\mu^{r}\left(1-\frac{J_{r}^{\mu^{r}}}{\sum_{r'}J_{r'}^{\mu^{r}}}\right)\frac{J_{rs}^{\mu^{s}}}{\sum_{s}J_{rs}^{\mu^{s}}}\frac{(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}}{\sum_{\tau}(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}} \\
\phi_{\tau}^{\tau'} &= -\mu^{\tau}P(\tau|r,s) + \mu^{s}(1-P(s|r))P(\tau|r,s) + \mu^{r}(1-P(r))P(s|r)P(\tau|r,s)
\end{aligned}$$

Since there are only two tasks it is also true that

$$\begin{aligned}
\phi_x^x + \phi_m^x &= \phi_m^m + \phi_x^m = \mu^s(1-P(s|r)) + \mu^r(1-P(r))P(s|r) \\
\phi_x^x - \phi_x^m &= \phi_m^m - \phi_m^x = \mu^{\tau}
\end{aligned}$$

The cross-elasticity with respect to a change in the wage in a task from a different industry in the same region is

$$\begin{aligned}
\frac{d\ln N_{rs'\tau}}{d\ln w_{rs\tau}} &= \frac{d\ln P(s'|r)}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}} + \frac{d\ln P(r)}{d\ln J_r}\frac{d\ln J_r}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}} \\
&= -\mu^{s}\frac{J_{rs}^{\mu^{s}}}{\sum_{s}J_{rs}^{\mu^{s}}}\frac{(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}}{\sum_{\tau}(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}} + \mu^{r}\left(1-\frac{J_{r}^{\mu^{r}}}{\sum_{r'}J_{r'}^{\mu^{r}}}\right)\frac{J_{rs}^{\mu^{s}}}{\sum_{s}J_{rs}^{\mu^{s}}}\frac{(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}}{\sum_{\tau}(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}} \\
&= -\mu^{s}P(s|r)P(\tau|r,s) + \mu^{r}(1-P(r))P(s|r)P(\tau|r,s) \\
&= (-\mu^{s} + \mu^{r}(1-P(r)))P(s|r)P(\tau|r,s)
\end{aligned}$$

The cross-elasticity with respect to a change in the wage of labor supply to a task in an industry in a different region is

$$\begin{aligned}
\frac{d\ln P(r')}{d\ln w_{rs\tau}} &= \frac{d\ln P(r')}{d\ln J_r}\frac{d\ln J_r}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}} \\
&= -\mu^{r}\frac{J_{r}^{\mu^{r}}}{\sum_{r}J_{r}^{\mu^{r}}}\frac{J_{rs}^{\mu^{s}}}{\sum_{s}J_{rs}^{\mu^{s}}}\frac{(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}}{\sum_{\tau}(\alpha_{rs\tau}w_{rs\tau})^{\mu^{\tau}}} \\
&= -\mu^{r}P(\tau|r,s)P(s|r)P(r) \\
&= -\mu^{r}P(\tau,r,s)
\end{aligned}$$

The ratio of new hires to an industry-region from within the same region and from other regions is exactly the same as in the previous model, see equation (14).

## B.3 Effects of immigration

Below I derive the results I use in Section 5.2. The supply of manual tasks consists of the sum of $I$, the number of immigrants, and $M_N$ the number of natives who choose to provide manual tasks, $M = M_N + M_I$. Hence,

$$\begin{aligned}
\frac{dM}{dM_I} &= \left(\frac{dM_N}{dw_m}\frac{dw_m}{dM} + \frac{dM_N}{dw_x}\frac{dw_x}{dM}\right)\frac{dM}{dM_I} + 1 \\
\frac{d\ln M}{d\ln M_I} &= \frac{M_N}{M}\left(\frac{d\ln M_N}{d\ln w_m}\frac{d\ln w_m}{d\ln M} + \frac{d\ln M_N}{d\ln w_x}\frac{d\ln w_x}{d\ln M}\right)\frac{d\ln M}{d\ln M_I} + \frac{M_I}{M} \\
\frac{d\ln M}{d\ln M_I} &= \frac{s_i}{1 + s_n\left(\phi_m^m\left(-\frac{d\ln w_m}{d\ln M}\right) - \phi_x^m\frac{d\ln w_x}{d\ln M}\right)}
\end{aligned}$$

The effect of immigration on the relative wage between manual and interactive tasks is given by $\frac{d\ln\frac{w_x}{w_m}}{d\ln M} = \frac{d\ln w_x}{d\ln M} - \frac{d\ln w_m}{d\ln M}$ and using (21) and (20) simplifies to the expression in equation (22). Similarly, the effect of immigration on the relative quantity of $X$ and $M$ is

$$\begin{aligned}
\frac{d\ln\frac{X}{M}}{d\ln M} &= \frac{d\ln X}{d\ln M} - \frac{d\ln M}{d\ln M} \\
&= \phi_x^x\frac{d\ln w_x}{d\ln M} + \phi_m^x\frac{d\ln w_m}{d\ln M} - 1
\end{aligned}$$

Finally, the total effect on the number of native workers in an industry is found as follows

$$\begin{aligned}
\frac{d\ln(X + M_N)}{d\ln M} &= \sum_{\tau=(x,m)}\left(\frac{d\ln P(s|r)}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}} + \frac{d\ln P(r)}{d\ln J_r}\frac{d\ln J_r}{d\ln J_{rs}}\frac{d\ln J_{rs}}{d\ln w_{rs\tau}}\right)\frac{d\ln w_{rs\tau}}{d\ln M} \\
&= \left(\mu^s(1 - P(s|r)) + \mu^r(1 - P(r))P(s|r)\right)\left(P(x|r,s)\frac{d\ln w_{rsx}}{d\ln M} + P(m|r,s)\frac{d\ln w_{rsm}}{d\ln M}\right) \\
&= \left(\phi_x^x + \phi_m^x\right)\left(\frac{X}{X + M_N}\frac{d\ln w_{rsx}}{d\ln M} + \frac{M_N}{X + M_N}\frac{d\ln w_{rsm}}{d\ln M}\right)
\end{aligned}$$

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**Figure 1: Fraction of Foreigners in Total Employment**

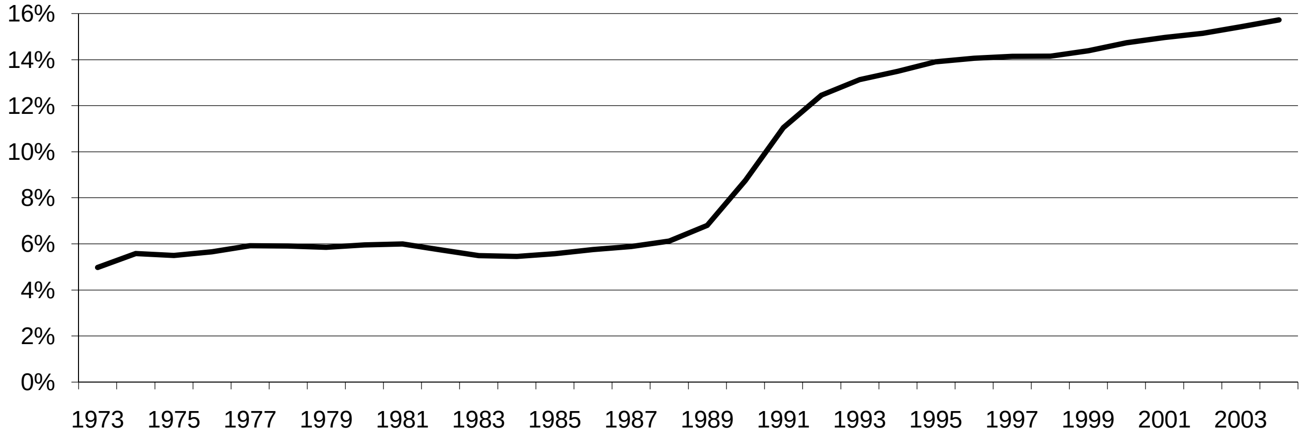


**Figure 2: Foreigners by Origin (in millions of days worked)**

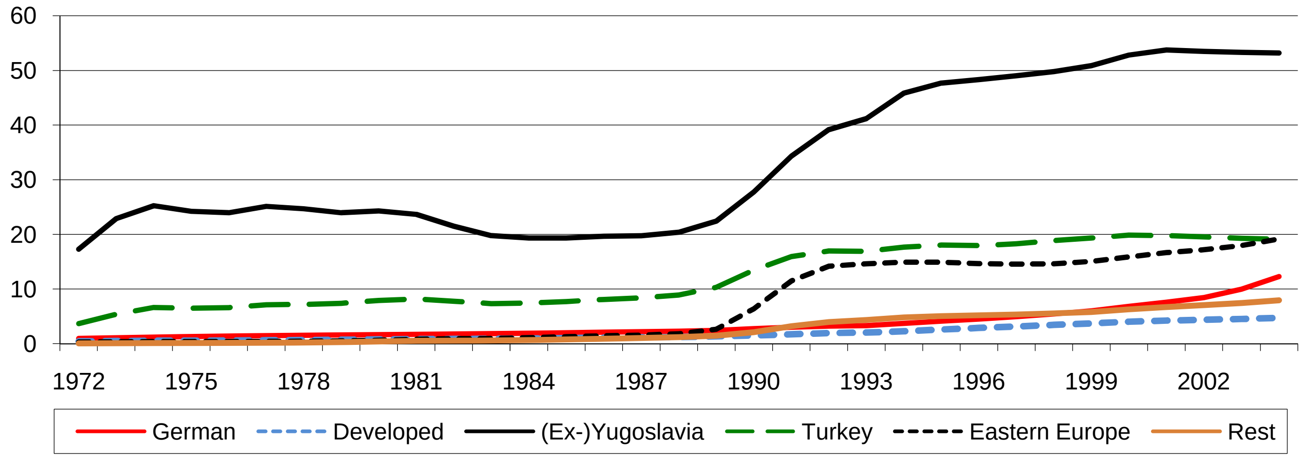


**Figure 3: Fraction Foreign Employment by Region in 1986 and 2004**

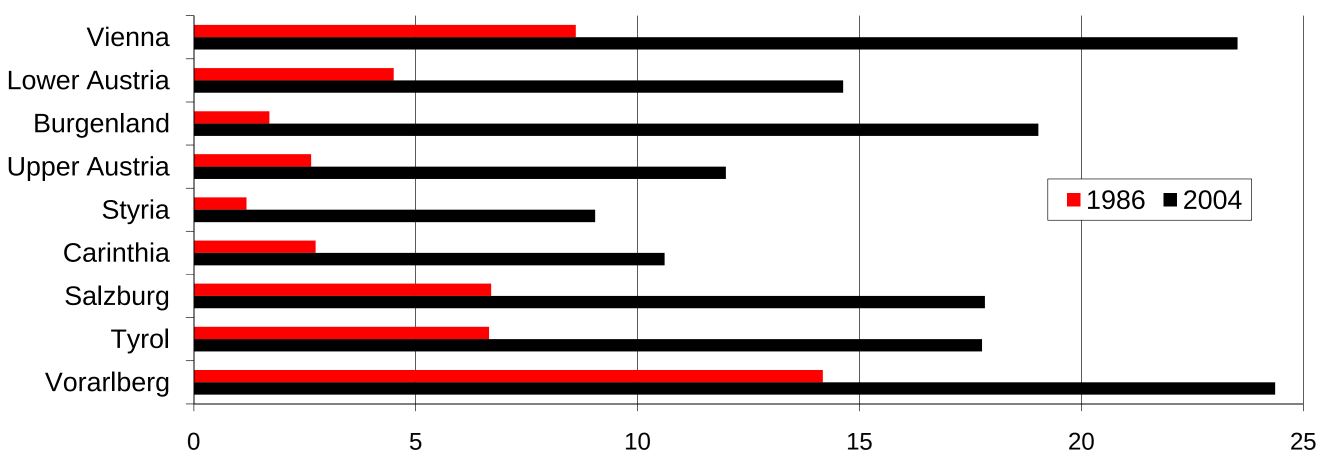

**Table 1: Summary Statistics**

| | Manufacturing | | Services | | All Industries | |
|---|---|---|---|---|---|---|
| | **1986** | **2004** | **1986** | **2004** | **1986** | **2004** |
| Fraction Foreign (in %) | 5.8 | 12.9 | 4.8 | 16.1 | 5.3 | 16.2 |
| Share Foreign (in %) | 5.2 | 11.0 | 4.0 | 13.7 | 4.6 | 13.7 |
| Relative Wage Foreign (in %) | -11.2 | -17.7 | -19.7 | -19.4 | -15.1 | -20.1 |
| Fraction Low Skilled (in %) | | | | | | |
| Foreign | 78.4 | 66.8 | 75.6 | 67.8 | 77.3 | 67.6 |
| Native | 36.2 | 23.4 | 30.0 | 27.9 | 32.3 | 26.8 |
| Fraction Blue Collar (in %) | | | | | | |
| Foreign | 84.1 | 77.1 | 78.4 | 71.5 | 82.0 | 75.0 |
| Native | 62.8 | 53.9 | 46.2 | 42.2 | 54.3 | 47.2 |
| Fraction Female (in %) | | | | | | |
| Foreign | 28.5 | 25.1 | 43.8 | 46.5 | 31.2 | 36.4 |
| Native | 35.4 | 26.7 | 50.1 | 54.1 | 40.2 | 44.5 |
| Average Age (in years) | | | | | | |
| Foreign | 35.6 | 36.8 | 33.8 | 33.5 | 35.1 | 34.6 |
| Native | 32.9 | 35.8 | 31.6 | 34.6 | 32.3 | 35.0 |

**Table 2: Actual Immigration on Predicted Immigration (by 1-digit industry)**

Dependent variable: Log Change in Immigrant Employment

| | Manufacturing | All Services | Construction | Retail Trade | Food & Acc. | Bus. Services | All Industries |
|---|---|---|---|---|---|---|---|
| Instrument | 0.328*** | 0.282*** | 0.275*** | 0.319*** | 0.237 | 0.377*** | 0.301*** |
| | (0.057) | (0.082) | (0.078) | (0.079) | (0.157) | (0.065) | (0.04) |
| Partial R-squared | 0.25 | 0.14 | 0.20 | 0.24 | 0.18 | 0.28 | 0.21 |
| No. Observations | 1296 | 1290 | 486 | 648 | 324 | 324 | 3234 |

* signficant at 10%; ** significant at 5%, *** significant at 1%. Unit of analysis is a 2-digit industry in a region in a year. Observations are weighted by the number of employees in each cell. All regressions include 2-digit industry by year fixed effects and region fixed effects for each industry. Standard errors are clustered on 2-digit industry by region cells and are robust to heteroscedasticity.

**Table 3: Correlation of Instrument with Changes in Native Wages and Employment in Pre-period (1981-85), by 1-digit industry**

Dependent variable: Log Change in Native Employment / Log Change in Native Wages / Log Change in Immigrant Wages

| | Manufacturing | All Services | Construction | Retail Trade | Food & Acc. | Bus. Services | All Industries |
|---|---|---|---|---|---|---|---|
| | | | | **Foreign Wages** | | | |
| Instrument | -0.049*** | -0.001 | -0.007 | -0.04 | -0.01 | 0.006 | -0.001 |
| | (0.012) | (0.004) | (0.009) | (0.038) | (0.006) | (0.008) | (0.004) |
| Partial R-squared | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 |
| No. Observations | 360 | 360 | 135 | 180 | 90 | 90 | 900 |
| | | | | **Native Employment** | | | |
| Instrument | -0.036*** | -0.04 | -0.024 | -0.042*** | -0.045 | -0.017 | -0.036*** |
| | (0.012) | (0.032) | (0.021) | (0.011) | (0.028) | (0.02) | (0.015) |
| Partial R-squared | 0.040 | 0.010 | 0.010 | 0.120 | 0.030 | 0.010 | 0.010 |
| No. Observations | 360 | 360 | 135 | 180 | 90 | 90 | 900 |
| | | | | **Native Wages** | | | |
| Instrument | -0.001 | 0.007 | -0.016 | 0.001 | -0.003 | -0.001 | 0.001*** |
| | (0.003) | (0.005) | (0.009) | (0.005) | (0.006) | (0.003) | (0.003) |
| Partial R-squared | 0.000 | 0.010 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 |
| No. Observations | 360 | 360 | 135 | 180 | 90 | 90 | 900 |

* signficant at 10%; ** significant at 5%, *** significant at 1%. Unit of analysis is a 2-digit industry in a region in a year. Observations are weighted by the number of employees in each cell and estimates are robust to heteroscedasticity. I cluster on 2-digit industry by region and all regresions include 2-digit industry by year fixed effects.

**Table 4: Impact of Immigration on Changes in Immigrant Wages (by 1-digit industry)**

Dependent variable: Log Change in Immigrant Wages

| | **All Services** | | **Manufacturing** | | **Construction** | | **Retail Trade** | | **Food & Accomm.** | | **Business Services** | | **All Industries** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** |
| Δ Log Foreign Emp. | -0.065** | -0.09*** | -0.075*** | -0.218*** | -0.043*** | -0.046* | -0.026 | -0.089*** | -0.009 | -0.172 | -0.158*** | -0.089 | -0.067*** | -0.107*** |
| | (0.032) | (0.027) | (0.012) | (0.076) | (0.014) | (0.027) | (0.035) | (0.032) | (0.014) | (0.127) | (0.056) | (0.059) | (0.015) | (0.025) |
| Partial R-squared | 0.05 | | 0.09 | | 0.08 | | 0.03 | | 0.07 | | 0.12 | | 0.07 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 486 | 486 | 648 | 648 | 324 | 324 | 324 | 324 | 3240 | 3234 |

* signficant at 10%; ** significant at 5%, *** significant at 1%. Unit of analysis is a 2-digit industry in a region in a year. Observations are weighted by the number of employees in each cell. All regressions include 2-digit industry by year fixed effects and region fixed effects for each industry. Standard errors are clustered on 2-digit industry by region cells and are robust to heteroscedasticity.

**Table 5: Impact of Immigration on Changes in Native Wages and Employment (by 1-digit industry)**

Dependent variable: Log Change in Native Employment / Log Change in Native Wages

| | **All Services** | | **Manufacturing** | | **Construction** | | **Retail Trade** | | **Food & Accomm.** | | **Business Services** | | **All Industries** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** | **OLS** | **IV** |
| | | | | | | | **Change in Log Native Employment** | | | | | | | |
| Δ Log Foreign Emp. | 0.125*** | -0.069* | 0.158*** | 0.152*** | 0.043*** | 0.037 | 0.132* | -0.098*** | 0.03 | -0.391 | 0.146*** | 0.072 | 0.121*** | 0.019 |
| | (0.042) | (0.041) | (0.022) | (0.074) | (0.011) | (0.027) | (0.073) | (0.048) | (0.02) | (0.275) | (0.044) | (0.059) | (0.022) | (0.024) |
| Partial R-squared | 0.2 | | 0.22 | | 0.33 | | 0.22 | | 0.09 | | 0.2 | | 0.2 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 486 | 486 | 648 | 648 | 324 | 324 | 324 | 324 | 3240 | 3234 |
| | | | | | | | **Change in Log Native Wages** | | | | | | | |
| Δ Log Foreign Emp. | 0.003 | -0.023 | 0.008 | 0.008 | 0.008* | -0.002 | 0.02 | -0.005 | 0.014 | -0.144 | -0.035* | -0.04 | 0.006 | -0.011 |
| | (0.014) | (0.018) | (0.006) | (0.013) | (0.005) | (0.008) | (0.019) | (0.014) | (0.01) | (0.092) | (0.019) | (0.049) | (0.007) | (0.009) |
| Partial R-squared | 0.04 | | 0.01 | | 0.07 | | 0.08 | | 0.02 | | 0.05 | | 0.04 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 486 | 486 | 648 | 648 | 324 | 324 | 324 | 324 | 3240 | 3234 |

* signficant at 10%; ** significant at 5%, *** significant at 1%. Unit of analysis is a 2-digit industry in a region in a year. Observations are weighted by the number of employees in each cell. All regressions include 2-digit industry by year fixed effects and region fixed effects for each industry. Standard errors are clustered on 2-digit industry by region cells and are robust to heteroscedasticity.

**Table 6: Impact of Immigration on Changes in Native Wages and Employment (by 1-digit industry)**

| Dependent variable: | Foreign Wages | | | | Native Employment | | | | Native Wages | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Services | | Manufacturing | | All Services | | Manufacturing | | All Services | | Manufacturing | |
| | OLS | IV | OLS | IV | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| | | | | | Without Region Fixed Effects | | | | | | | |
| Δ Log Foreign Emp. | -0.063*** | -0.095*** | -0.077*** | -0.191*** | 0.139*** | -0.053 | 0.17*** | 0.158*** | -0.002 | -0.028** | 0.008 | 0.008 |
| | (0.029) | (0.028) | (0.012) | (0.055) | (0.037) | (0.055) | (0.021) | (0.054) | (0.013) | (0.016) | (0.005) | (0.012) |
| Partial R-squared | 0.03 | | 0.09 | | 0.12 | | 0.17 | | 0 | | 0.01 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 1296 | 1296 | 1296 | 1290 | 1296 | 1296 | 1296 | 1290 |

* signficant at 10%; ** significant at 5%, *** significant at 1%. Unit of analysis is a 2-digit industry in a region in a year. Observations are weighted by the number of employees in each cell. All regressions include 2-digit industry by year fixed effects. Standard errors are clustered on 2-digit industry by region cells and are robust to heteroscedasticity.

**Table 7: Differential Impact of Immigration on Changes in Native Employment and Wages**

| Dependent variable: | Difference High to Low Education Workers | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Native Employment | | | | Native Wages | | | |
| | All Services | | Manufacturing | | All Services | | Manufacturing | |
| | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| Δ Log Foreign Emp. | -0.042*** | 0.007 | -0.057*** | -0.042 | 0.004 | 0.002 | 0.004 | -0.009 |
| | (0.015) | (0.03) | (0.011) | (0.031) | (0.009) | (0.015) | (0.004) | (0.012) |
| Partial R-squared | 0.61 | 0.6 | 0.34 | 0.34 | 0.56 | 0.56 | 0.24 | 0.23 |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 1296 | 1296 | 1296 | 1290 |
| Dependent Variable: | Difference Female to Male Workers | | | | | | | |
| | Native Employment | | | | Native Wages | | | |
| | All Services | | Manufacturing | | All Services | | Manufacturing | |
| | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| Δ Log Foreign Emp. | -0.073*** | 0.055 | 0.004 | 0.036 | -0.013* | 0.009 | 0.004 | 0.027* |
| | (0.027) | (0.04) | (0.019) | (0.05) | (0.007) | (0.015) | (0.005) | (0.016) |
| Partial R-squared | 0.42 | 0.37 | 0.24 | 0.23 | 0.61 | 0.61 | 0.46 | 0.45 |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 1296 | 1296 | 1296 | 1290 |
| Dependent Variable: | Difference White Collar to Blue Collar Workers | | | | | | | |
| | Native Employment | | | | Native Wages | | | |
| | All Services | | Manufacturing | | All Services | | Manufacturing | |
| | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| Δ Log Foreign Emp. | -0.103*** | 0.032 | -0.062*** | -0.078** | 0.006 | 0.014 | 0.001 | 0.005 |
| | (0.023) | (0.043) | (0.012) | (0.033) | (0.013) | (0.021) | (0.004) | (0.012) |
| Partial R-squared | 0.5 | 0.46 | 0.34 | 0.34 | 0.55 | 0.55 | 0.29 | 0.29 |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 1296 | 1296 | 1296 | 1290 |

* signficant at 10%; ** significant at 5%, *** significant at 1%. Unit of analysis is a 2-digit industry in a region in a year. Observations are weighted by the number of employees in each cell. All regressions include 2-digit industry by year fixed effects and region fixed effects for each industry. Standard errors are clustered on 2-digit

**Table 8: Parameter Estimates for Framework I**

| | All Services | Manufacturing |
|---|---|---|
| Elasticity of Substitution ($\sigma_{in}$) | 13.4 | 3.7 |
| Elasticity of Product Demand ($\psi$) | 0.4 | 22.1 |
| Elasticity of Labor Demand ($\eta$) | 0.6 | 15.8 |
| Elasticity of Labor Supply ($\phi_n$) | 4.1 | 12.1 |
| Within region scale parameter ($\mu_s$) | 3.9 | 11.4 |
| Between region scale parameter ($\mu_r$) | 1.5 | 5.2 |
| | | |
| Hire (s'\|r) / Hire (r') | 2 | 2 |
| Immigrant labor share ($s_i$) | 0.103 | 0.097 |
| Native labor share ($s_n$) | 0.897 | 0.903 |
| Total labor share ($s_q$) | 0.7 | 0.7 |
| Capital share ($s_k$) | 0.3 | 0.3 |
| | | |
| Elasticity with respect to immigration of: | | |
| Average wages | -0.03 | -0.014 |
| Price of final output | -0.021 | -0.01 |
| Total employment | 0.041 | 0.234 |

**Table 9: Impact of Immigration on Hire and Separation Rates and Wage Changes for New Hires and Incumbent Workers**

| | New Hires | | | | | |
|---|---|---|---|---|---|---|
| | All Services | | Manufacturing | | All Industries | |
| | OLS | IV | OLS | IV | OLS | IV |
| Δ Log Foreign Emp. | 0.052*** | -0.04*** | 0.059*** | 0.097* | 0.048*** | 0.024* |
| | (0.01) | (0.021) | (0.011) | (0.055) | (0.006) | (0.013) |
| Partial R-squared | 0.45 | | 0.11 | | 0.36 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 3240 | 3234 |
| Dependent variable: | Separations | | | | | |
| | All Services | | Manufacturing | | All Industries | |
| | OLS | IV | OLS | IV | OLS | IV |
| Δ Log Foreign Emp. | -0.073*** | 0.029 | -0.099*** | -0.055 | -0.073*** | 0.005 |
| | (0.035) | (0.042) | (0.017) | (0.064) | (0.018) | (0.022) |
| Partial R-squared | 0.3 | | 0.19 | | 0.28 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 3240 | 3234 |
| | Change Wages of New Hires | | | | | |
| | All Services | | Manufacturing | | All Industries | |
| | OLS | IV | OLS | IV | OLS | IV |
| Δ Log Foreign Emp. | 0.002 | 0.007 | 0.006 | 0.043 | -0.005 | 0.011 |
| | (0.027) | (0.041) | (0.014) | (0.048) | (0.014) | (0.025) |
| Partial R-squared | 0 | | 0 | | 0 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 3240 | 3234 |
| | Change Wages of Incumbent Workers | | | | | |
| | All Services | | Manufacturing | | All Industries | |
| | OLS | IV | OLS | IV | OLS | IV |
| Δ Log Foreign Emp. | 0.007 | -0.024 | 0.005 | -0.003 | 0.008 | -0.013 |
| | (0.014) | (0.016) | (0.005) | (0.012) | (0.007) | (0.009) |
| Partial R-squared | 0.05 | | 0.01 | | 0.04 | |
| No. Observations | 1296 | 1296 | 1296 | 1290 | 3240 | 3234 |

* signficant at 10%; ** significant at 5%, *** significant at 1%. Unit of analysis is a 2-digit industry in a region in a year. Observations are weighted by the number of employees in each cell. All regressions include 2-digit industry by year fixed effects and region fixed effects for each industry. Standard errors are clustered on 2-digit industry by region cells and are robust to heteroscedasticity.